# DISCOVERY

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# DISCOVERY

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*Edited by C. P. SNOW*

*NEW SERIES, VOL. I*

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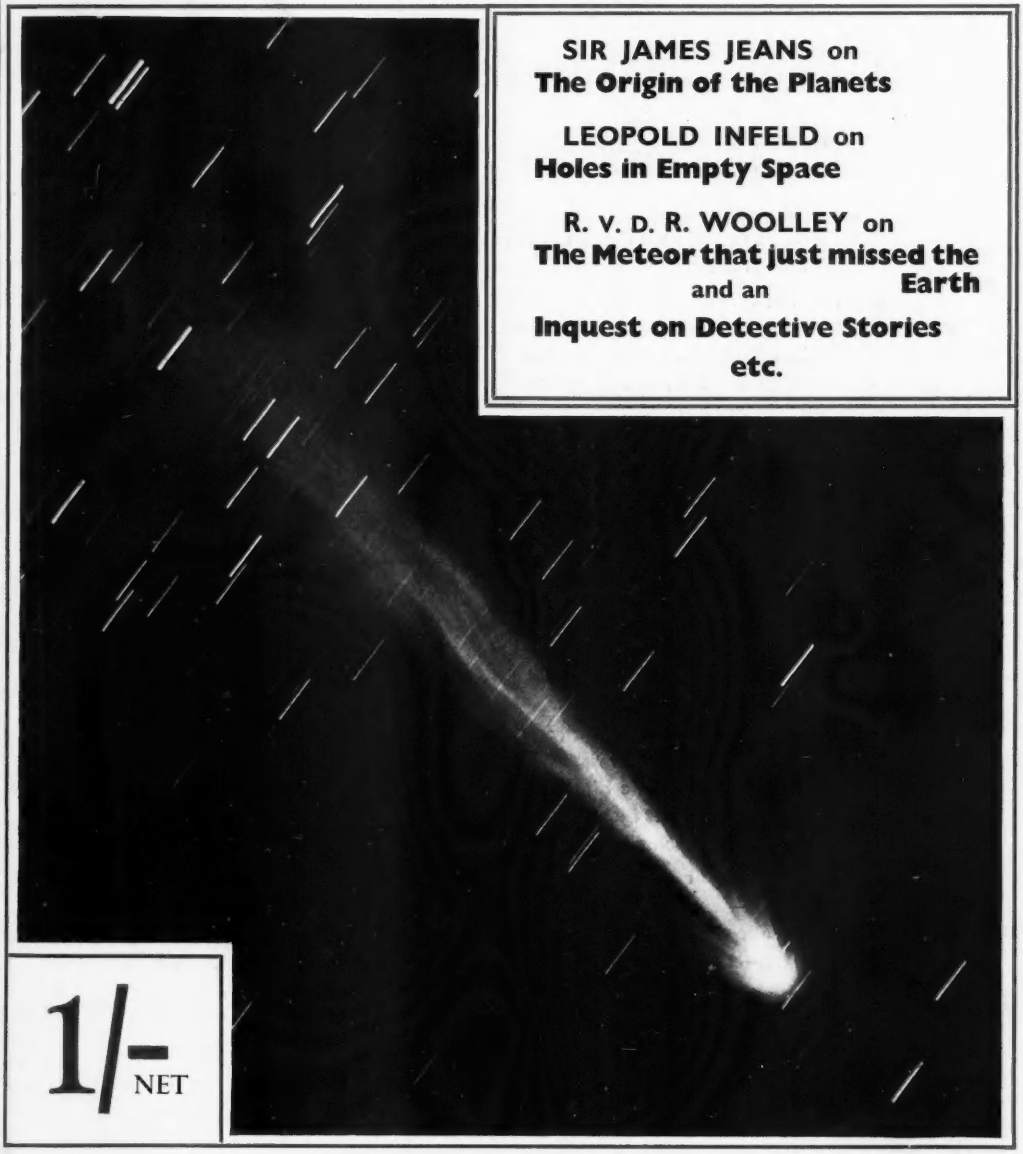

**SIR JAMES JEANS** on
**The Origin of the Planets**

**LEOPOLD INFELD** on
**Holes in Empty Space**

**R. V. D. R. WOOLLEY** on
**The Meteor that just missed the Earth**
and an
**Inquest on Detective Stories**
**etc.**

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# THE ENDS OF THE EARTH

TRAVEL and adventure are not in the news every day. But when they are *The Times* is the best and often the only place where you can read about them.

To recall only a few of the more recent instances, *The Times* had exclusive rights in the 1924 Everest expedition, when Irvine and Mallory were lost; in Sir Hubert Wilkins's flight over the North Pole; in Gino Watkins's two Greenland expeditions; and in Bertram Thomas's crossing of the Rub'al Khali.

This year the full story of the 1938 Mount Everest expedition under Mr. H. W. Tilman will be published exclusively in its columns; as was the tale of Lord Clydesdale's flight over the world's highest summit.

Full-dress expeditions are comparatively rare in these days. In the intervals between them readers of *The Times* are given a generous ration of more personal, less professional adventure. Miss Freya Stark, for instance, is even now in the Hadramaut with a commission from Printing House Square—a commission of the kind which took Mr. Peter Fleming to Tartary and to Brazil.

In the last two years alone *The Times* has published the first independent account (Mr. H. P. Smolka's) of Soviet Russia's vast domains in the Arctic, the narratives of Mr. Robert Byron in Siberia, Miss Audrey Harris in Afghanistan, Mr. Peter Keenagh in Honduras, Mr. Alan Villiers in the far-ranging ship Joseph Conrad; as well as a wide variety of other travellers' tales, among the most notable of which were Mr. Ronald Kaulback's account of his two years in Tibet and Mr. Spencer Chapman's story of his casual, single handed conquest of the 26,000 foot Chomolhari.

In the columns of *The Times* explorers are able to tell their story as they wish to tell it—truthfully, straightforwardly and vividly, without sensationalism or exaggeration. Their photographs—thanks to the skill of *The Times* Art Department—are beautifully reproduced. The maps which accompany their articles are the finished work of experts.

**THE TIMES**

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# DISCOVERY

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## *Discovery* comes to Cambridge

NEW discoveries are being made every day. Unless we are lucky enough to have had a special training, we hear nothing about them. If by accident we do see an account of a discovery, it is either wildly inaccurate, or else written in a technical language that we cannot understand.

So we are shut off from some of the most exciting things in the world to-day. The present time is not a peaceful one, but for those who are occupied with the search for knowledge it is full of exhilaration. This century has been lit up with the glow of successful discovery. In science, in particular, it has been a golden age.

Unless we understand these achievements of our day, we miss one of the greatest rewards of being alive in the twentieth century.

Every means ought to be used to explain these results. They ought to be within the reach of the interested layman, even if he does not possess the time or training to follow all the technical details. The advance of knowledge, indeed, ought to be made as easy to understand as is humanly possible. It was for this purpose that *Discovery* was founded, just after the War. The original trustees, Sir J. J. THOMSON, Sir FREDERIC KENYON, Sir ALBERT SEWARD and the late Professor R. S. CONWAY, were men who themselves had made great contributions to knowledge. They felt it their duty to help others to share in the pleasure of understanding. In 1920 they inaugurated a "monthly popular journal of knowledge". The first publisher was John Murray (1920–24); from 1924 to the present issue, the journal was published by Benn Brothers.

Now the Trustees have made over their responsibility to the Syndics of the Cambridge University Press. In the name of the University Press, we should like to

thank the Trustees both for their vision and for its realization during the last seventeen years. We wish to continue *Discovery* according to their main principles: first, that the knowledge in it shall be accurate; second, that it shall be as universal as possible. The journal will not be wholly "scientific" in the narrow sense. There will be much science in it; that is inevitable, since an important scientific discovery is made every week. There will be as much physics, astronomy, biochemistry, medicine, as we can find room for. Nor shall we neglect the other branches of science. We shall feel guilty if a major scientific discovery does not get notice in our pages. We shall also, however, print articles on archaeology, travel, architecture, and a good deal else—anything, in fact, which increases knowledge and which a good many people are likely to find interesting to read.

Last, but not least, we must present the knowledge as clearly and attractively as possible: if we fail there, we fail altogether. We believe that this first issue under the new imprint will justify our intentions, but we shall welcome the suggestions and help of all our readers.

To present new knowledge to the public seems to us to be worth every effort, and we hope readers of *Discovery* will do their part in the attempt.

*(From "The Ascent of Nanda Devi", by H. W. Tilman.)*

"Longstaff's" Col (19,200 ft.) and Nanda Kot (22,500 ft.).

SUMMER

*By* Walter Benser

A photograph taken at one-thirtieth of a second (aperture f/4·5) on New Agfacolour film with a Leica camera. *See article on p.* 45.

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# The Origin of the Planets

## By Sir James Jeans

ACCORDING to the famous nebular hypothesis of Laplace, the planets were born out of the sun while this was still a vast nebular mass, larger than any known star. As this mass cooled it shrank, and as it shrank it continually spun faster and faster, as required by the well-known principle of the conservation of angular momentum. In time a speed was reached at which the nebula could no longer hold together as a single body; just as a fly-wheel breaks up if it is spun too fast, so the great nebula broke up, and the planets were formed out of the débris.

Laplace believed that the shrinking sun broke up by a process of continuously leaving matter behind in its equatorial plane. At first each particle of matter would go on revolving round the sun just as it did while it still formed part of the sun's equator. At a later stage, the whole assemblage of left-behind matter would condense into a planet, after which the process would begin again, until a second planet was born, and so on.

We of to-day believe that a stream of gas slowly liberated from the equator of a rotating sun would not condense into planets; its atoms or molecules would scatter into space, precisely as the molecules of coal-gas do when we turn the gas-tap on in the laboratory, and for the same reason. Condensation can, and must, occur when the matter is so abundant that its gravitational attraction outweighs the tendency to molecular scattering, but on the relatively puny scale contemplated by Laplace it cannot possibly occur.

Laplace pointed to the rings of Saturn as evidence that the process he had in mind could really occur, and a study of these rings will show us the difference between Laplace's views and those of to-day. In these rings Laplace saw a satellite before its birth; we see in them a satellite after its death.

* * * *

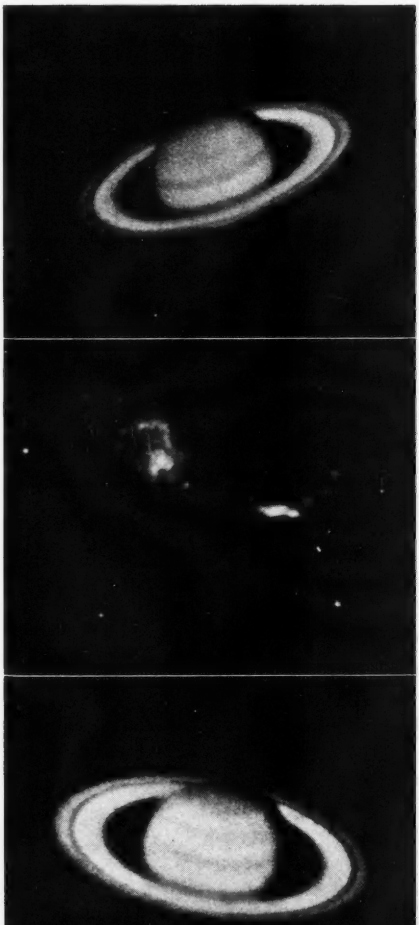
To understand this, let us examine the ordinary everyday tides which the moon raises on our earth. There are the well-known tides in the ocean which are of moderate height, because water is easily pulled about, and in addition there are the "body-tides" in the solid body of the earth, which are smaller than the foregoing because rock is denser and more rigid than water. These are caused by the moon's gravitational pull on the earth, but the earth exerts a far stronger gravitational pull on the moon, with the result that there are far larger "body-tides" in the moon. If the moon came closer in to the earth, these body-tides would become greater still, but there is a limit to their magnitude. In 1852 a French mathematician

showed that if a small body comes too near to a larger gravitating body, tides are inadequate to relieve the strain. Instead of huge tides being raised, the small body is pulled to pieces. We believe that in remote future ages, the moon is destined to come closer and ever closer in to the earth. As it does so, the tides which the earth raises in the moon will for ever increase, until finally the moon will no longer be able to hold together as a single body, but will break into fragments. We shall no longer have a single moon, but a swarm of minute satellites like the rings of Saturn, to light our earth at night.

What our earth's satellite will do in the future, we believe that a satellite of Saturn must have done in the past. Its orbit, we think, continually contracted until the strain of Saturn's tide-raising gravitational field became too great for it, and broke it into the fragments we now see.

The sky shows other examples of the same phenomenon. Comets have been seen breaking into two or more pieces under the gravitational field of the sun. Others have been found to break up between successive apparitions—probably in the gravitational field of Jupiter. Bode's law tells us there ought to be a planet between Mars and Jupiter; instead we find a swarm of fragments—the asteroids. Again it looks as if the planet had been broken up, probably by Jupiter's field.

The tidal theory of the origin of the solar system—at any rate in the form in which I propounded it in 1916—supposes that the planets were produced by a rather similar process. If the sun, in the course of its wanderings through space, passed near to a second and more massive star, tides would be raised on its surface. But the two bodies might come so near that tides alone could not relieve the strain. In such a case, mathematical analysis



The middle photograph shows two nebulae (N.G.C. 4395, 4401) which suggest tidal action. The others are of Saturn's rings—"a satellite after its death".

shows that gaseous tides would rise continually higher on the sun until the limit was reached, when a long filament of gas would suddenly shoot out towards the other star. When the two bodies finally receded from one another the matter of this filament would be left suspended in space, endowed with a motion of revolution round the sun which would prevent its falling back into the sun. It would finally condense into globules of gas of about the same size as planets. The theory suggests that these are the actual planets. They would describe elliptic orbits about the sun and, if they came near enough to the sun, might themselves be broken up and give birth to systems of satellites.

* * * *

The theory seems capable of explaining many of the observed features of the solar system. It explains at once why the planetary motions have reference to two planes—the plane of the sun's rotation, and the plane in which the outer planets revolve. Clearly the former must have been the plane of rotation of the original sun, while the latter would be the plane in which the second star passed by the sun. Again it explains why the largest planets, Jupiter and Saturn, are found in the middle of the sequence of planets, while the size tails off at either end. For these central planets would be formed of matter which was emitted when the two stars were at their closest approach—the stage in which matter would be emitted more profusely. Again these central planets, being the largest, would cool most slowly, and from this it can be deduced that they ought to be surrounded by numbers of small satellites, while the smaller planets at the two ends of the series should be surrounded by a few relatively large satellites. Actually there is a regular sequence in the number of planetary satellites—0, 0, 1, 2, ?, 9, 9, 4, 1, ?. The tidal theory at least makes this intelligible, while no other theory with which I am acquainted even attempts to explain it. On the other hand, the theory undoubtedly has its difficulties. The most serious is, perhaps, one which has recently been pointed out by Prof. H. N. Russell. It is, in brief, as follows.

Unless the visiting star comes quite close to the sun's surface—usually to within two or three of the sun's radii from this surface—planets will not be born from the encounter; tides will rise and fall again, and that is all. Thus the encounter on which the tidal theory relies must have all happened well within the orbit of Mercury. What forces, then, have shot out Pluto to 100 times the distance of Mercury's orbit, and the great mass of Jupiter to 13 times this distance?

If we knew the mass of the visiting star, we could calculate the greatest distance of approach which is consistent with planets being born. The angular momentum of the star in this orbit is then the maximum permissible; with more angular momentum there will be no planets. Actually this upper limit is found to depend only slightly on the unknown mass of the visiting star, varying less rapidly than its sixth root, so that we shall not go far wrong if we calculate the limiting angular momentum for a star of average mass.

It is very hard to see how the passing star can impart more angular momentum per ton to the planetary matter than it possesses itself, so that if planets are formed, we should expect each planet to have less angular momentum than is fixed by this upper limit. But the actual planets have more in every instance—25 times more for Pluto, 9 times more for Jupiter, and so on. Where did it come from?

A. R. Lyttleton has tried to solve the puzzle by supposing that the sun was originally one constituent of a binary system, the other constituent having been captured by the second star of the tidal theory. He believes that this hypothesis permits of the planets having their observed orbits, but Luytens and Hill have challenged his analysis, and the issue is still in doubt.

* * * *

Dr Jeffreys and others have drawn attention to a further difficulty inherent in all theories which suppose that the sun and planets originally formed one body. The sun rotates once in about twenty-six days, Jupiter once in ten hours. The matter which now forms Jupiter, and now rotates once every ten hours, must at some time, so these theories suppose, have rotated once only in twenty-six days. What then can have produced the increased rate of rotation? Not mere shrinkage, since if this were the only cause operating, the original Jupiter must have been larger than the sun. Some external forces must have got a rotational grip on the matter of Jupiter and set it spinning faster, and the same with most of the other planets. The difficulty is to find any external force of sufficient potency.

Jeffreys has proposed that the tidal action of a second star should be replaced by a grazing collision with a second star. Then the matter near the point of collision is caught between the upper and nether millstones formed by the two stars and set into rapid rotation. This comes very near to the "collision" hypothesis propounded by Bickerton of New Zealand. Calculation shows that this hypothesis is quite consistent with the observed rotations of the planets, but grazing collisions must be very, very rare events in star-land.

* * * *

Milne has recently developed a very revolutionary system of dynamics in which angular momentum does not stay constant in the absence of external forces, but increases steadily with the time. This of course removes all difficulties which arise from excess of rotation and angular momentum, not only from this problem, but from many other problems of cosmogony. But it has not so far gained many adherents.

In spite of these various very real difficulties, the many successes of the tidal theory seem to indicate, in my opinion at least, that it is fundamentally sound. We may, I think, still hope that modifications will be found which will remove all its apparent inconsistencies.

# Holes in Empty Space. *By* L. INFELD

*(Dr Infeld is a mathematical physicist now working at Princeton. He is a pupil of Professor Einstein's; the two of them have recently collaborated in a popular explanation of the fundamental ideas of physics. This book, the title of which is "The Evolution of Physics", was published simultaneously a few days ago in this country and U.S.A.)*

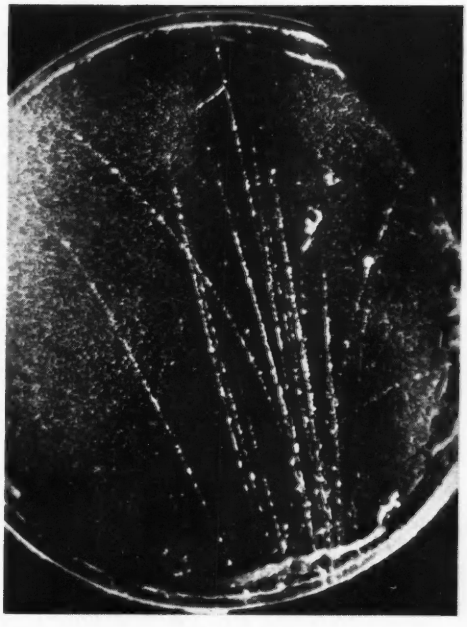
Is it possible to imagine something simpler than empty space? Surely a complete vacuum must be simpler than any material thing. Yet the study of this apparently simplest of all physical concepts led to the prediction and discovery of a new material particle, the *positron*.

We know that empty space, or if we prefer to call it so, the *ether*, has a very important physical property: it carries electromagnetic waves, such as light and radio waves. Has the ether also other properties? Before we tell how modern physics answers this question, let us describe a simple analogy which will help us to understand the problem of empty space.

Imagine a billiard room whose walls are composed of a single layer of billiard balls. In order to play a game we extract some balls, leaving as many holes in the wall. The room now has (1) a few balls on the table, with which to play; (2) an enormous number of balls forming the walls; (3) holes in the walls corresponding to the balls taken out of them. The existence of two kinds of balls (those on the walls and those on the billiard table) and the existence of the holes form a picture which we shall keep in mind to help us to understand the answer to the physical questions with which we began.

* * * *

Let us return to physics. Professor Dirac, in a most important paper published a few years ago, arrived at a strange conclusion. According to his theory the elementary negatively charged particle, called the electron, may equally well have positive or *negative* energy. Even to physicists this notion was at first meaningless, for energy had been considered as a quantity which must always be positive. Only in a lunatic asylum could we find people saying, "In this room there are seven less than no people at all", or "I smoked minus twenty cigarettes to-day". It was thought nonsense to apply negative numbers to energy and mass. In Dirac's theory, which made clear many previously unexplained physical phenomena, electrons of negative energy



One of the photographs which confirmed the existence of the *positron*. Negatively charged particles (electrons) are moving to the *left* of the picture: positively charged to the *right*. (Blackett and Occhialini.)

play a definite role, although in reality we not only fail to observe such particles in nature but also cannot even imagine their existence. Nevertheless there *is* some sense in the concept of electrons with negative energy. Dirac understood that the paradoxical notion of negative energy forces us to revise our older concepts of vacuum. Returning to our billiard room we could say: matter which can be detected by experiment corresponds to the balls on the table. Electrons of negative energy cannot be detected, but, according to Dirac, they exist throughout the universe in infinitely greater numbers than those of positive energy. In our comparison they correspond to the balls composing the walls of the room. Empty space is, then, like such a wall, completely covered and has no irregularities whatever. In physical language empty space is an infinite and continuous distribution or "sea", as Dirac likes to call it, of negative energy electrons. The two kinds of billiard balls, those on the table and those on the walls, correspond then to two kinds of electrons: those with positive and those with negative energy.

But are we not playing with obscure and meaningless speculations? If space filled with negative energy electrons behaves exactly like empty space, it is impossible to prove their existence by any experiment. We shall see in a moment, however, that there is one consequence of this conception of the universe which can be experimentally verified. It was just this confirmation, found by Anderson in America, by Blackett and Occhialini at the Cavendish Laboratory in Cambridge, which was one of the greatest achievements of experimental physics in recent years.

* * * *

We reach the climax of our story: there are, in the analogy of the billiard room, besides the balls on the table, the holes in the walls from which these balls were taken. Extracting a ball from the wall and placing it on the table corresponds to a transfer of an electron from a negative energy state to one of positive energy. Thus matter is born in empty space! There must be, of course, an agency for such creation, just as a ball will not jump from wall to table of its own accord. The role of extractor of balls is played by highly energetic gamma radiation and cosmic rays which, in their journey through empty space, are able to lift an electron from a negative to a positive energy state. But it is obvious that *two* things happen when one takes down a ball: a new ball appears on the table and simultaneously a new hole appears in the wall.

To clear up the whole problem we must thus answer one more question. What corresponds to the hole in the wall? What is the "hole" which occurs in space when an electron of negative energy is extracted? The answer forms a further essential point of our story. Dirac found that a hole in this "sea" of negative energy behaves exactly like a positive electron with positive energy—that is, like an elementary particle whose mass is equal to that of the ordinary electron, but whose charge is of the *opposite sign*. This particle has been called a *positron*. We have seen that radiation may be capable of changing an electron from negative to positive energy. In other words, radiation can create a pair of particles, electron and positron. If we wish to speak with a certain amount of bathos we may say that space is soil which, impregnated by radiation, can give birth to twins of elementary particles. This interpretation of empty space was splendidly confirmed by Anderson and by Blackett and Occhialini, who found experimentally the creation of positrons by cosmic rays. To-day physicists in their laboratories all over the world are observing positrons.

There is one further point on which we may remark. In our analogy there were as many holes in the walls as balls on the table. We repeat:

Billiard balls on the table correspond to *electrons of positive energy*.

Balls on the walls correspond to *electrons of negative energy*.

Holes in the walls correspond to *positrons*.

Our comparison would mean that there are as many electrons (of positive energy) as positrons, but this is not the case in the world as we know it. Electrons are common and have been known for many years. Positrons are rare, and were discovered only five years ago. Dirac's views on this subject are highly interesting, and there is no more fitting conclusion to this article than the sentences with which he closed his Nobel lecture in 1933:

"If we accept the view of complete symmetry between positive and negative electric charge so far as concerns the fundamental laws of nature, we must regard it rather as an accident that the earth (and presumably the whole solar system) contains a preponderance of negative electrons and positive protons. It is quite possible that for some of the stars it is the other way about, these stars being built up mainly of positrons and negative protons. In fact, there may be half the stars of each kind. The two kinds of stars would both show exactly the same spectra, and there would be no way of distinguishing them by present astronomical methods."

# The Meteor that just missed the Earth

## By R. v. d. R. Woolley

*(Dr Woolley is engaged on astronomical research at the Observatories of Greenwich and Cambridge. He gives us here an authoritative account of an event which attracted much attention early this year.)*

There are now known to be nine major planets in the solar system. There are also a very large number of smaller bodies, which are called minor planets. It is one of the minor planets provisionally called 1937 UB which caused a mild sensation a few months ago by making a close approach to the earth, and raising the question whether an impact between one of these bodies and our own planet may be expected to occur in the future.

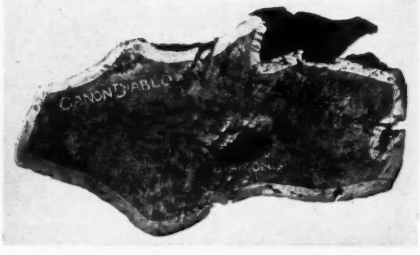
Meteoric Iron found at Rowton in Shropshire. Weight 7¾ lb. Date of fall April 20, 1876. (Natural History Museum.)

Collisions with meteors of considerable size are believed to have occurred in the past. There is a well-known crater in Arizona (picture on p. 11) which is attributed to the falling of an object or swarm of objects on to the earth's surface at that point. The crater is very remarkable: it is about 4000 ft. in diameter and has a rim which rises about 150 ft. above the surrounding plain. On the inside, the walls of the crater descend precipitously to a floor 600 ft. below the top of the rim. Within 5 miles of the crater, thousands of iron meteorites have been picked up, and the rocks at the bottom of the crater show signs of having been crushed, and of

having been heated strongly at some time. Trees growing on the rim are estimated to be seven hundred years old, and the geological evidence seems to point to the crater having been formed in modern times, perhaps a few thousand years ago. There are similar craters forming a group in the deserts of Australia. Very recently —in 1908—a great meteor fell in a deserted area in Siberia, the impact generating a pressure wave in the atmosphere of sufficient force to knock down the trees over an area comparable to that of an English county. Still, even if we allow for the fact that most impacts of this sort must take place in the sea and leave no trace, it is quite clear that a collision between the earth and any body sufficiently large to do considerable damage is a rare event in history. On the other hand, the damage which would be done by a meteor as large as the Siberian meteor, let alone one as large as the Arizona meteor, would be very considerable if it fell in a populated area, and catastrophic in the improbable event, even given that a fall is going to take place somewhere, that it will take place in a city.

The ordinary meteor is a small object, stony or ferrous, which is not seen until it strikes the earth's atmosphere, when the heat developed by friction makes the meteor incandescent, that is to say, a "shooting star". Nearly all of them are so small that they are entirely consumed before they reach the ground. There may or may not be a dividing line between meteors and minor planets other than that of mere size: but we may, for convenience, speak of a mass of stony or ferrous composition controlled by the sun's gravitational field as a minor planet if it has been observed by reflected sunlight and while it is outside the earth's atmosphere. Of course there is no case known to astronomical history of an impact between a minor planet, defined in this way, and the earth.

It should be possible, given a certain number of observations of a minor planet, to determine its orbit and to predict its subsequent movements for all time: but while this is possible in principle, it is usually very difficult in practice. In a very exact discussion of the movements of planetary bodies, that is to say, bodies moving under the influence of the sun and its satellites, we should have to say that planetary bodies moved according to the law of gravitation given by Einstein's theory of relativity: but in all practical applications save one (the motion of the innermost planet, Mercury) it is sufficient to say that the bodies move, within the limits of accuracy with which we can observe their



Polished slice, showing a large carbonaceous inclusion containing diamond, of the Meteoric Iron found in 1891 at Cañon Diablo, Arizona. (Natural History Museum.)

motions, according to Newton's law of gravitation. Unfortunately for astronomers, Newton's law of gravitation—the inverse square law—while it affords us a solution which we can handle with neatness and dexterity to the problem of two bodies moving under their mutual gravitation, does not possess a solution to the problem of three or more bodies that has anything like the same simplicity, and the problem of three bodies has only been solved by approximate and cumbrous methods. There are, of course, far more than three gravitating bodies in the solar system: as far as the minor planets are concerned, the principal factor is of course the sun, with the major planets as disturbing influences.

Naturally the degree of disturbance depends on the closeness of any approaches to any major planet, and any minor planet which comes in so close to the sun as to

The meteor crater in Arizona (photographed from 5000 ft.). The crater is 600 ft. deep, 4000 ft. from rim to rim. The white specks at the bottom of the crater are houses.

menace the earth must of necessity in some circumstances pass close not only to the earth but also to Mars and possibly Venus. Its orbit may, therefore, be highly disturbed by these bodies, and if we want to work out its movements for all time we must start out with a very accurately determined path over at least one revolution round the sun. We could then work on the predicted approaches to disturbing bodies and find out a new orbit after each approach.

Unfortunately it was impossible to get a good orbit for 1937 UB. When at its closest, the little planet was of the eighth magnitude, and so too faint to be seen by the naked eye. As it moved away, of course it got fainter, and while it was close to us, its apparent motion among the stars was very great, so great that the planet was lost after a few days' following. Its orbit is so uncertain that the period has been given as one year by one computation and four years by another. It is not certain that we shall see it again, nor is it certain that if we do see it we shall be able to recognize it. It was never more than a faint speck without any features, and we can only guess its size vaguely, since we are deprived in this case of the normal method of weighing planetary bodies by gravitational disturbance. For example, Mimas, a small satellite of Saturn, has had its mass determined by its gravitational effect on the Saturn system. As Mimas is always in the Saturn system, small disturbances due to Mimas can be studied in a way which does not apply to an independent wanderer like 1937 UB, which is much smaller than Mimas. Mimas has a diameter of 370 miles and about one two-thousandth part of the mass of our moon. Now 1937 UB was of the eighth magnitude when distant 400,000 miles from the earth, while Mimas is of the twelfth magnitude (forty times as faint) when distant 800,000,000 miles. If we assume that 1937 UB has the same density and surface brightness as Mimas, its diameter must be about 1 mile and its mass about $10^{-11}$ times the mass of the moon, or about a thousand million tons.

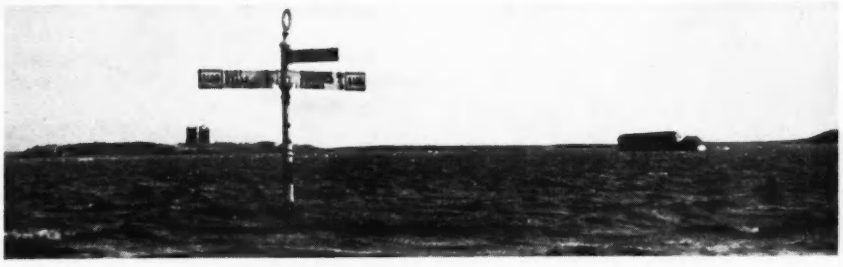
There is one thing above all which lets us hope that we shall never be hit by this pygmy among planets, but super-giant among meteors. It is the theoretical suggestion that the earth must by now have swept up all the minor planets whose orbits are such that a collision is at all possible. Accordingly, objects like 1937 UB have only survived the passage of the millions of years since the formation of the solar system because there is some feature of their orbits which saves them from collision with the major planets.

*(By permission of H.M. Stationery Office.)*

Sunken forest seen at low tide off the coast of Lincolnshire. (Geological Museum.)

# *England is Sinking!*

By F. H. MACKINTOSH



Sea floods at Salthouse, Norfolk, on February 14, 1938.

MANY young people alive to-day may live to see all the London bridges heightened or their arches reformed, and the famous view of the Thames from the Embankment blocked by a high wall. It would be a strange experience to walk along the riverside of the Embankment and hear the hoots of tug sirens *overhead*. Yet this is a definite possibility of the future.

London is sinking. It has been doing so for 5000 years at the rate of an inch in just over five years. This may seem too slight to be worth consideration, but during the whole period there has been a drop of 80 ft. This is the maximum height allowed for buildings in the Metropolitan area without special permission, so that it has sunk enough to submerge the high buildings of the present day. If this sinking business simply went on evenly, one lifetime would be too short to bring about any noticeable difference. It is because the process is irregular that the next fifty years may show startling changes.

### The Thames Bank in Tudor Times

There are many ways in which geologists can ascertain what has happened in the past, and forecast with reasonable accuracy what is likely to happen in the future. Some of their evidence can be checked historically. For instance, it is well known that in the reign of Henry VIII, Cardinal Wolsey built the Bridewell Palace at Blackfriars on the Embankment. The famous cardinal would not be likely to build a palace where the ground floor would be flooded at every high tide. It is also known that the site had previously been an orchard, and fruit trees will not grow on soil that is washed by tides, nor will they thrive on supplies of brackish water. It is certain, therefore, that the site of Wolsey's palace was above high-water level.

Yet when the foundations were being laid for Unilever House on the same spot, the palace wharf was discovered 7 ft. below ordinary high-tide level of the present day. At the time it was built this wharf must have been at least a foot above the high-tide level because owners of riverside houses strolled upon their wharves to take the air in the evenings.

All this provides clear evidence that, since Tudor times, there has been a sinking of at least 8 ft. in only 400 years. But geologically there is more certain evidence than this to be found at Tilbury Marshes, the great stretch of low-lying land on which London's dockland is situated. It has been

discovered that this area is built up of five distinct layers of peat, which contain fragments of willows, hazels, alders and similar trees. Each of the peat beds is covered by a layer of gravel, and each layer of gravel by a layer of mud.

This formation tells a simple story. A layer of peat containing fragments of trees shows that, for about 200 years, the area must have been above water. But the gravel shows that beyond question the whole site must have been more or less suddenly submerged. There was not even time for the existing trees to decay. They were washed away and broken up. Their fragments remain to this day. Then the last layer of mud shows that this process of sinking that caused the flooding must have slowed up. This layer could only have been formed where the land was covered with shallow water, only slightly affected by tides.

### A Period of Sinking has begun

So London has not sunk in regular stages. There have been periods of as long as 200 years when the subsidence entirely ceased, followed by periods of such quick sinking that wide areas were flooded. The five distinct beds at Tilbury reveal that this cycle sinking, flooding and then the sudden cessation of sinking has been repeated five times over. Moreover there is reason to believe that one of the periods of quick sinking has recently begun.

Some years ago the authorities were taken by surprise by serious flooding at Millbank, when several lives were lost. No change had been made in the height of the Thames walls since the Embankment was built in the early nineteenth century. Yet suddenly came this flooding, while evidence from the coast showed that it was not caused by an abnormally high tide. There had been a sudden drop in the level of the land. Since then the sinking movement has continued, because although the walls at the flood-points were heightened after the first serious inundation, each period of high tides in the spring and autumn brings anxiety.

How serious this question of subsidence can be is shown by the fate that has overtaken several English coastal towns within historical times.

In Roman times a flourishing town called Regulbium stood some three miles inland from a point now occupied by Margate. To-day all that remains of Regulbium consists of two towers on the sea shore at Reculver. In the reign of Edward the Confessor, we read, "A great sea flood spread wide over the land, overwhelmed many towns, and an innumerable multitude of people were drowned." At the time of this inundation a group of islands in the North Sea was entirely swallowed up.

### Submerged Towns on the English Coast

An instance of a town that has actually "gone to sea" is Old Winchelsea. Up to

Flooding at Millbank, London. Men erecting emergency sandbank barricades.

the beginning of the 13th century, this was a busy, fortified city on the coast not far from where Rye now stands. It was finally overwhelmed in 1287, and now lies a few miles out to sea from Rye. The site of the present Winchelsea was given to the surviving inhabitants by the King. It was at the same time that the Zuyder Zee was formed, where previously there had been only a small fresh-water lake.

Dunwich in East Suffolk was a victim of this same subsidence, and Dunwich was the most important commercial centre in East Anglia. It had suffered from sea encroachment in the eleventh century, and was almost destroyed in 1347. It was rebuilt further inland, but in 1570 it was destroyed again. To-day Dunwich lies some miles out to sea off the Norfolk coast.

Many people imagine that these immersions are due to the sea eating away the coast line, but in fact they are entirely due to the sinking of land. There is no such thing as coast erosion without subsidence. Where there is no sinking movement, the sea batters at the cliffs, bringing down quantities of rock and shingle, which forms a barrier round the base of the cliff, thus protecting it from further attack. But where a subsiding motion is in process this barrier sinks with the cliffs. It is covered by the sea at high tides and washed away, leaving the cliffs again exposed at the base. (See, however, the editorial note at the end of this article.)

Ruins of the fishing village at Hall Sands, Start Point, Devon.

### The Movements of the Earth's Crust

Since the whole of the earth's crust is in a state of perpetual motion, this movement is not confined to England, and it is beyond the power of man to control. Few people realize that the whole of the Himalayan range, including Mount Everest, 29,002 ft. high, was once the bed of a deep sea!

The British Isles have been submerged repeatedly, only to be thrust up again, but they have spent much more time under water than above it. In fact only 10 per cent of our history has been spent above the water. Yet for a period of perhaps a quarter of a million years, both the North and Irish Seas did not exist. The land extended from Norway to Spain, and protruded into the Atlantic beyond Ireland. At this time the Rhine, which now flows into the North Sea on the Dutch coast, flowed across a plain, which is now the bed of the North Sea. It is interesting to note that the forest that covered this plain still exists under the sea, for at low water the stumps of trees can be seen off the east coast (see the picture on p. 12). This was when the Thames was merely a tributary of the Rhine! Geologically this was the heyday of the British Isles, for our average altitude was at least 1000 ft. higher than

at present. Snowdon and Ben Nevis were capped with perpetual snow.

There is no more regularity about these vast movements of land than there is about small local movements, but subsidence or elevation on such an immense scale is spread over thousands of years. There is thus no risk that our near posterity will be faced with such problems. But movements such as that at present going on in London act much more quickly, and it is for each generation to provide safeguards. Although the authorities are hardly likely to jeopardize the capital of the country, the margin between safety and disaster is only narrow, and at best some of the most thickly populated parts of London are only a few inches above danger level.

### A Tide Five Feet above the present Level

A tide only 5 ft. above the present high level would prove disastrous. Many parts of South London would be flooded. The water would pour over the Embankment walls, all the docks, the East End, Pimlico and Chelsea would be under water. The floods would probably cover the ground floor of Buckingham Palace. A tide 15 ft. above present level would be a national catastrophe, for the sea waves would then reach as far as Molesey above Richmond. A great part of Essex and Kent would be submerged, and Romney Marsh would cease to exist. Even the west coast would be affected, for Cardiff would be inundated, and a great lake formed between Cheddar and Bridgwater.

Fortunately these are improbabilities, but the point is that they are not impossibilities. Abnormally heavy western gales in the Atlantic piling up water in the North Sea and English Channel, in conjunction with floods in the Thames from heavy rainfall and a high spring tide, would defeat our present defences. In such circumstances a tide of 5 ft. above normal high levels would be a definite possibility.

However, the subsidence now going on is not an accidental or chance happening. It is a geological movement that can be gauged, and its progress is slow enough to enable ample measures to be taken. Gradually the walls of the Embankment and all river defences will have to be strengthened and raised as the drop becomes apparent. New formation of bridge arches will be an early precaution, for since an arch closes towards the top, it tends to become a dam if the level of the river is higher in relation to the banks and bridge. It is essential to maintain a free flow for the swollen waters of the tides, as any obstruction would only raise them still higher.

Again, the Thames is one of the busiest waterways in the world. Even above the bridges there is much traffic, large cargo boats navigating as high as London Bridge, while schooners, barges and colliers proceed even as far as Isleworth. Sufficient clearance must be kept under all bridges to enable this traffic to pass freely.

Mechanical science, modern ideas of architecture and new schemes of town planning are all changing the face of our cities, but there is no factor so likely to bring changes in London as this fact that London is sinking. Some day, perhaps, she will have disappeared altogether, to join the ill-fated towns of Old Winchelsea, Regulbium and Dunwich beneath the waves. But fortunately that is a prospect of the far-distant future.

(Mr Mackintosh has put forward a most interesting view about coast erosion. It is worth remarking, however, that this is an unsettled and controversial subject. Much of the most authoritative geological opinion considers that coast erosion can proceed without any reference to the sinking of land. EDITOR, *Discovery*.)

# Notes of the Month

*Under this heading there will appear regularly a number of items of scientific news. Most of these will be short accounts of discoveries made within the past few weeks.*

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AFTER Rutherford's discovery of the nuclear atom, it seemed that the material universe could be constructed out of two particles—the *electron* and the *proton*. The proton was known to be positively charged, the electron negatively charged: the proton was about 1800 times heavier than the electron. For about twenty years these were the only elementary particles yet discovered. Since then, however, the position has become nothing like so simple. In his article "Holes in Empty Space", Dr Infeld describes the discovery of the *positive electron*—a particle of the same mass as the electron, but oppositely charged. In 1932 Chadwick discovered the *neutron*—as heavy as the proton, but with no charge at all. It will be noticed, however, that these particles were either of the same mass as electrons on the one hand, or protons on the other. There seemed nothing between the two.

Very recently (early this year) it has been suggested that another kind of particle exists. According to the new suggestion, this particle is negatively charged like the electron—but its mass falls in the forbidden country between electron and proton. The mass is, in fact, about 100 times that of the electron. The particle is provisionally called the *heavy electron*.

(Yukawa, Japan)

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The star called $\epsilon$ Aurigae has just been discovered to be the largest yet known. It is actually one of the most remarkable objects in the universe. It is a *double* star, consisting of one very large "infra-red" star and one much smaller which contributes all the light we see. The "infra-red" star is quite cool and dark. Its radius is 3000 times that of the sun. The largest known before this was Antares, with a radius of 450 times that of the sun.

(O. Struve, Yerkes University, U.S.A.)

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Work on the *growth hormones* of plants is giving results of great interest. These hormones (exactly like the vitamins and hormones of animals) are substances which are necessary for the plant's growth: necessary, again like vitamins and hormones for animals, in extraordinarily small quantities. How they work, either

in plants or animals, no one yet knows. But there is nothing mysterious about the substances themselves—they are being shown to be ordinary chemical substances, some of which can already be made in the laboratory. Thus, if one takes nasturtiums which have been growing in soil for fourteen days and transfers them to sand which is moistened with a weak solution of an ordinary laboratory substance called "1-naphthyl-acetic acid", they grow much more rapidly. *Too much hormone, however, kills the plants.*

The "tops" of lettuce plants were increased 300 per cent. in weight by adding the equivalent of about a quarter of an eggspoonful of this same chemical to an acre.

(These examples: N. H. Grace, Ottawa)

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Very severe tests have just been made on *homing* in birds. Swallows have been shown to find their homes from a distance of 1000 miles. Later still, storks have been taken by aeroplane as far as 1400 miles from home. As soon as they were set free, they circled round exactly like carrier pigeons. Soon they found their direction. A large proportion travelled methodically back along the straight line they had come. They made about 110 miles a day, and most of them arrived safely. There seems no escape from the explanation that some species of birds possess a special "sense of orientation".

(Wodzicki, Pucholski and Liche, Warsaw)

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*Pithecanthropus* (the ape-man of Java) was a genuine man-like creature. There used to be controversy about whether he really was anything like a man, or merely an enormous gibbon. Now another skull of *Pithecanthropus* has been found; and it proves that he must have been close to the line of man. He seems, in fact, to have been very much like the Peking man, *Sinanthropus*. They probably lived about the same time, some hundreds of thousands of years ago. *Sinanthropus* had already discovered fire and the use of stone tools.

They were more man-like than ape-like. But neither *Pithecanthropus* nor *Sinanthropus* is a true ancestor of modern man. They are early off-shoots who have left no descendants.

(Weidenreich, Peiping)

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A delegation of the British Association visited India in December and January. Their hosts were able to meet and listen to Jeans, Darwin, Eddington, and other great English scientists. The delegation, on their side, enriched themselves by studying Indian science at first hand.

This visit emphasized once more that science is international. It recalled also the romantic career of Ramanujan. In 1911 Ramanujan was a poor clerk in Madras, who had *failed* in his B.A. examination at Madras University. He was still a very

young man, but had spent much time for years past in private mathematical researches. He was advised to send some of his results to the English mathematician, G. H. Hardy; within a few hours of receiving them, Hardy realized that they were the work of a man of genius. Money was found, and Ramanujan came to England.

In a few years he produced a volume of original discoveries which are still occupying the attention of some of the most gifted European mathematicians. He was elected a Fellow of Trinity College, Cambridge, and of the Royal Society. He died in 1920: he was then just over thirty years of age.

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At the end of February W. L. Bragg was elected to succeed Lord Rutherford in the Cavendish Chair of Experimental Physics. This chair has come to occupy a unique position among the scientific professorships of the world. The four previous holders have set a standard of the highest possible achievement. For sixty years the Cavendish has been the greatest experimental centre of the great days of physics. It is extraordinarily lucky that in Professor Bragg there is someone of the same stature to follow on.

The first Cavendish Professor was Clerk Maxwell (1874–9). It is interesting to remember that the chair was first offered to the German physicist, Helmholtz. Clerk Maxwell was the theoretical counterpart of Michael Faraday, and his famous equations became the final statement of "classical" physics. He was incidentally a man of whimsical humour and charm, and took a mischievous delight in puncturing the dignity of his more pretentious colleagues. He died young, and was succeeded by Lord Rayleigh (1879–84), an experimental scientist of great versatility —perhaps his most important discovery was that of the group of inert gases.

Then Sir J. J. Thomson (1884–1919), the discoverer of the electron, on which "modern" physics has depended. It was during J.J.'s tenure that the Cavendish first reached its high mark of international fame. He is now Master of Trinity, and can be seen on most days, walking without an overcoat—in the middle of a Cambridge winter—towards one of the University sports grounds.

Then Lord Rutherford (1919–37)—so much has been written in the last few months about his record of fundamental discoveries, the nuclear atom, transmutation of elements, and so on, that it is unnecessary to repeat it here. No one doubts that he was one of the very greatest scientists. He was also full of a rich, warm and boisterous humanity. He exuded a cheerful Jehovianic quality, which he enjoyed and knew other people enjoyed. One day in a shop, someone overheard a quite unusual commotion behind a screen. The assistant explained, with a subdued chuckle, that it was Lord Rutherford being measured for a shirt. Then a tremendous bellow of laughter, followed by Rutherford's booming voice: "Every day I grow in girth—*and* in mentality."

Professor Bragg, the fifth of this line, won a Nobel Prize at 25 for his pioneer work in crystallography. No other scientist has ever obtained this distinction so young.

(In this number we include an article on "The Cavendish Laboratory To-day".)

# *Ethnography and the Cinema*

## ROBERT FLAHERTY'S VALUABLE WORK

### By WINIFRED HOLMES

ETHNOGRAPHY has a new weapon in its armoury—the movie-camera. Robert Flaherty, the well-known director of *Nanook of the North*, *Moana*, *Man of Aran* and *Elephant Boy*, has discovered and made use of its unique possibilities and properties for ethnographic discovery and documentation. Before the War, prospecting for iron-ore for Sir William Mackenzie along the shores of Hudson's Bay, he came upon Eskimos who had never before had contact with white man and whose culture and religion—the worship of spirits, with the medicine man as the tribe's doctor and priest—were pure and uninfluenced by contemporary civilization.

He longed for some means by which he could bring back more than written or photographed records of them, more than the mere material presence of empty dress or unhandled implements. Instead, he longed to show their life and move-

Brahmin boys putting on their caste marks (Mysore, South India).

Call to the Dance (Pueblo Indian).

ments, their physique, their facial expressions—in fact to bring them back as living people to the lecture rooms and museums of Europe and America.

On one such expedition he came upon a tribe of Eskimos dressed entirely in feathers! They were trekking to Cape Wolstoneholme from an island they had lived on for years to find wives for their sons, and told him that the island's moss had been entirely frozen over one particularly severe winter, and in consequence the deer had died of starvation. As there was no bear or hairy seal on the island, they had had to take the skins of eider ducks and sew them together, feathers and all, to make coverings for themselves. They too had never seen a white man and were aghast at his pink face, yellow hair and blue eyes until one of their babies smiled at him and broke the ice. From then on the whole tribe became his devoted friends and helped him as much as they could in his scientific interest in them and their customs. He was frozen up among them for a year, and his findings provided material for lectures to the National Geographic Society. The island, immediately south of Belchen Island, is now named Flaherty Island. But still he lacked the ability to take their movement and rhythm of life back with him to civilization.

While he was with them, however, and saw the whole yearly curve of Eskimo life he realized that a motion-picture camera would be the solution of his problem. So far the movie-camera had only been used artificially for entertainment. Stories were written or adapted from the stage to be photographed inside studios with

Brahmin—priest caste (Mysore, South India).

Pueblo Indian cacique.

Kurubar, aboriginal jungle man (South India).

made-up sets and actors and actresses. No one had thought of taking the camera out of doors and "shooting" real life material with ordinary people going about their jobs. Robert Flaherty was the first to see the cinema's immense possibilities for science—how really valuable a film biography of a group of people isolated culturally, uninfluenced by white civilization and still living a dangerous and exciting life close to nature, could be. He planned a film which would record the life of an Eskimo family—such as the people among whom he had been living—in its daily struggle for existence.

This film would show the important part the central figure, the father of the family, plays; his responsibilities—his fine skill in hunting and trapping, in reading weather signs, in judging distances and so forth—on which many lives depend; his womenfolk and their duties and blubber-fat babies; the training of his children to follow in his footsteps. It would show the philosophic attitude and communism of the Eskimo, whose fierce struggle with Nature makes it imperative that he should help all men and be helped in his turn—working for the common good against the common enemy. It would show something of the climatic conditions in which he lived and worked—the biting wind, the blizzards, the inexorable breaking of the ice, the way in which he wielded his implements, the way he walked, threw a harpoon, built an igloo, and his expressions of anxiety or of bland good humour—in fact, his very self.

Such a film would have a sharp and immediate impact on everyone who saw it, and be immensely valuable as a document of historic interest when Eskimo life has changed under the influence of the white man.

Robert Flaherty came back to civilization after his year among the feathered Eskimos with plans ready for *Nanook of the North*. But he found it hard to interest a backer in the project—films being an expensive form of making records. At last a sponsor came forward in Revillon Frères, a firm with interests in the North, and back again he went to Hudson's Bay to spend another year frozen up without mails or other form of communication with the outside world among a similar tribe; one which dressed, however, in the usual Eskimo garments of deer, bear or hairy sealskin.

Mixing Kava (Samoa).

The resulting film surprised the world and instantly became a huge success, although it was made primarily as an ethnographic study of a primitive people. Moreover, it revolutionized the cinema, taking writers and directors out into the open to look for subjects of real life, and was the pioneer of the present "documentary" film movement.

But more than that it proved a valuable aid to science, coming as it did just when the new trend in scholarship—to co-ordinate all branches of the study of mankind and survey of racial or cultural group as a whole—was beginning to be felt. This "scientific humanism", as I have called it elsewhere, condemns museums for displaying barren acres of dead objects and specimens unrelated to the humanity which made and used them; condemns the old methods of classification according to academic theory and prefers to treat of a civilization or race as a living as well as an historic entity.

The magnificent colonial museums of Holland—the Colonial Institute at Haarlem and the Ethnographical Museum, Leyden—pursue this policy with complete success. And they use films, such as *Nanook of the North*—the first ethnographic film ever to be made—as a vital part of their organization. We are slow in following suit in this country: our museums still being (with one exception—the India Museum, South Kensington) run on old academic lines. But informed public opinion is trying to have this state of affairs altered, when ethnographic films will be sought for and made.

After *Nanook of the North* Robert Flaherty cast about him for another ethnographic subject which would repay study and at the same time provide dramatic film material. His idea was always to concentrate on a racial group pure in feature and culture which had been left unspoilt and untouched by our own wide-spreading one, and which was in danger of dying out. The struggle of man with nature seemed to him more worthy of study than that of man with man, and he felt that film studies of this sort would be invaluable to students in every country.

The Nascaupe Indians of the Labrador Peninsula were his first thought. He had come across them in his old prospecting days when he was only armed with a still camera, and had then wished he could bring back a living record of them before they became extinct. The "Land of Little Sticks", as its people call it from its dwarf trees, lies in the hinterland of North Labrador between Hudson's Bay and Ungava

Eagle Dance (Pueblo Indians).

Bay, and is seldom visited by white men. Its inhabitants—pure Indians—contrast strongly with their neighbours, the Eskimos, being tall with a fine physique, and in temperament volatile, cheerful, noisy and excitable. In this respect they are very different from other Indians, perhaps because they are free and not oppressed by the supremacy of the whites. Living farther North than any other Indian tribes, they were pushed up there by the fierce Iroquois many centuries ago. Now they follow a nomadic life, sledging all over Hudson's Bay after its migratory herds of deer. The chief words in their language are "love" and "kill", and they are very jealous of their prestige and possessive over their women.

Unfortunately, Robert Flaherty could find no sponsor for this projected film record, and had to turn his thoughts elsewhere. The American Indians, he considered, would be wonderful material before they died out or were assimilated into the general American and Western culture. A preliminary survey showed him, however, that it would be almost if not quite impossible to break down the barriers of suspicion and bitterness they had set up between themselves and the white man who

had dispossessed them and destroyed their self-respect. A film study of this sort could only be made with the full co-operation of the people under review or it would have no value at all; and this co-operation, Robert Flaherty found, would be practically impossible to obtain.

So he abandoned the project and chose Samoa for his next field of study. A film company in Hollywood was ready to back a film of Samoan life provided it was "like *Nanook*". In other words, it must be a biographical exercise in the life and customs of a Samoan family, living in an out-of-the-way part where the ancient culture of the race was still intact. He had another reason for choosing the Samoans for this next study. He wished to contrast them with the Eskimos, whose struggle for existence is so fierce and unrelenting with the great common enemy, Nature. The Samoans have no struggle for existence; Nature is caressing and kind to them. What psychological difference would this different state of living reveal?

It took a long time—two years in fact—for Robert Flaherty to dig deep enough down to find the real ancient Samoan culture, even on the remotest island he could find. Everywhere missionaries had penetrated, and in their zeal overlaid many of the people's native beliefs and customs with a layer of Western civilization. But he did find it in the end, and before it vanished entirely, caught it and set it down in celluloid.

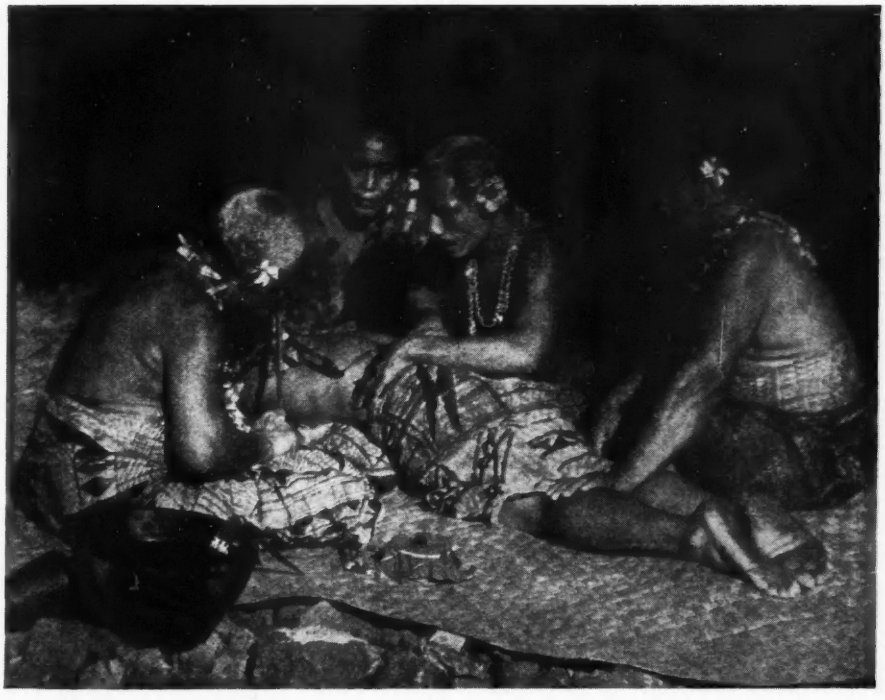
The film *Moana*, which was the result of this study, has for theme a family, and as in *Nanook of the North*, it shows the special duties and responsibilities of the father and the mother and their training of the children. We are shown the elaborate etiquette of courtesy and precedence—a creation of centuries—on which the Samoan social structure is based and which, if violated, is fiercely fought for.

Here where nature is friendly and not inimical to man, he fights violently with his brother for prestige. And though generous and lovable and communistic, the Samoan is easily offended and changed to a fierce warrior. All this, expressed so vividly in a turn of a hand, a change of facial expression from good-humour to insolent hostility, a correct contrasted with an offended bearing—all the signs of etiquette observed or deliberately broken—can be shown by film and by no other medium except that of the living people themselves. Film could show too the exquisite physique, the way they walk—an art civilized people have lost—and their singing and dancing and ceremonial ritual, which is largely expressed by means of flowers.

The dramatic climax of *Moana*—just as it is in real life—is the tattooing done at puberty. Although originally this must have had a magic significance, the exorcizing of the evil spirit within the body, it has grown to mean a necessary test of manhood; necessary to a people otherwise living a "soft" life. But after taking to clothes they are not only growing weaker and falling victims to tuberculosis, but are giving up the tattooing test, thereby losing their self-respect. Soon *Moana* will contain the only living—or illusion of living—record of this all-important ceremony.

Since making *Moana* Robert Flaherty has worked in Tahiti, Aran and Mysore, but the exigencies of the film industry have forced him to turn his ethnography into a commercial mould—to the great loss of science. With his sensitive awareness and ability to come closely into contact with primitive peoples and cultures, and with his wide ethnographic knowledge, he could make films—or rather living documents—of lasting scientific value in a world where many original cultures are dying out or being assimilated by our contemporary standardized and mechanized one.

Not only should all ethnographical museums, and those devoted to a single aspect of the study of mankind—anthropology, archaeology, ethnology, history and geography—collect films of this sort and use them with effect, but there should also be a museum of ethnographic films which would finance such records. Robert Flaherty considers that many of the peoples could make these films themselves, as the Bantus are doing at present. Primitive technique and simplicity of outlook would enhance rather than detract from their value as ethnographic documents.



Tattooing performed as an initiation test at puberty (Samoa).

# *Inquest on Detective Stories*

## By R. PHILMORE in consultation with J. YUDKIN

*(A great deal of ingenuity is being used by detective-story writers to construct new ways of scientific murder. It seemed to "Discovery" that some of these methods ought to be examined. So we have brought together a distinguished detective-story writer and scholar of detective fiction, Mr Philmore—and a medical man who has done original research in several different fields, Dr Yudkin. Mr Philmore selects five elaborate methods of murder, and asks Dr Yudkin if they would work.)*

Miss Dorothy Sayers.

THE detective story is the post-war version of the Victorian novel with a plot. The works of the old masters—Poe, Collins, Doyle, Bentley—were, comparatively speaking, rarities, an eccentric sideline. But they founded what we must now call a school. The credit for the enormous expansion of detective literature is due mainly to two writers—Wallace and Mason. Wallace we used to read furtively (or, alternatively, with unnecessary bravado) as a sort of reversion to our schooldays; we read easily, for he was such a great craftsman. Mason convinced us that a detective story could have style. The taste we got from our half-ashamed reading of Wallace made us thirst for more and more of this kind of book. The relish of Mason made us demand, as far as possible, literary qualities in them.

We allowed Wallace and Mason (and their less respectable contemporaries, like Rohmer) a great deal of latitude in their method of killing. We allowed Wallace to kill people with frozen pellets of snake-poison, or with bubbles of poisonous gas which could be blown through a window on to a victim's pillow. We allowed Mason to thrill us in that most fascinating of detective stories, *The House of the Arrow*, with a "poison which left no trace". In those days we laid our critical faculties aside when we took up a detective story. Ronald Knox had not yet proclaimed the rules which must be observed. Literary journals had not yet formed the habit of reviewing detective stories regularly.

### The Correct Murderer

But the age of the scientific detective story had already been ushered in by the publication of the classic *Mysterious Affair at Styles* by Agatha Christie in 1920. In this book, as every detective reader ought to know, the lines of the standard mystery story were laid down. Amongst other things, the murderous device was carefully planned, made to sound possible and easy, and was scientifically plausible—a harmless medicine, which contained a non-lethal proportion of poison, received an addition which caused the poison to form a precipitate, so that it was all taken in the last dose, which was fatal. From that book onwards Christie has effectively brought the Wallace fantasies down to plausibility, and has imposed her realism (with the aid of the critics) on her followers; while, of course, her style and characterization, if commonplace by the side of Mason's, have been good enough to prevent any but the purest from feeling distaste at reading her.

The increase in detective literature has forced writers to look for odder and odder methods of killing their victims. But they have not only to be odd: they must be plausible. Some of them make us ask a lot of questions of our medical friends. Here are five fairly recent examples of complicated killing—which have each been submitted for Dr Yudkin's opinion.

### Lord Peter's Bicycle Pump

First of all there is Dorothy Sayers' *Unnatural Death*. In this story we suspect that a woman has killed a number of people; she had motive enough, and opportunity—only, unfortunately, their deaths were all put down to heart failure. Lord Peter Wimsey discovers the secret. The murderer injected an air-bubble into an artery, and stopped the circulation. Here is Lord Peter's own description of the method of death (in conversation with a doctor).

"Look here, the body's a pumping-engine, isn't it? The jolly old heart pumps the blood round the arteries and back through the veins and so on, doesn't it? That's what keeps things working, what? Round and home again in two minutes—that sort of thing?"

"Certainly."

"Little valve to let the blood out; 'nother little valve to let it in—just like an internal combustion engine, which it is?"

"Of course."

"And s'posin' that stops?"

"You die."

"Yes. Now, look here. S'posin' you take a good big hypodermic, empty, and dig it into one of the big arteries and push the handle—what would happen? What would happen, doctor? You'd be pumpin' a big air-bubble into your engine feed, wouldn't you? What would become of your circulation, then?"

"It would stop it...."

"...the air-bubble, doctor—in a main artery—say the femoral or the big vein in the bend of the elbow—that would stop the circulation, wouldn't it? How soon?"

"Why, at once. The heart would stop beating."

"And then?"

"You would die."

"With what symptoms?"

"None to speak of. Just a gasp or two. The lungs would make a desperate effort to keep things going. Then you'd stop. Like heart failure. It would *be* heart failure."

Now, if one consults medical opinion, one finds some doubts thrown on the efficacy of this method. Here is the report I had:

(J. Y.) "The presence of air in the blood may cause death in either of two ways. It may lodge in the blood vessels supplying the brain, causing death in coma by cutting off the blood supply to some vital part. Or it may embarrass the action of the heart, causing heart failure, by creating a froth in the chambers of the heart with which the heart cannot deal. The entry of air into the circulation occurs most commonly in operations on the neck. It may occur, too, during an attempt to inject air into the chest (pneumothorax) when the needle inadvertantly enters a vein.

"In practice, however, death does not commonly occur in these cases. So it is difficult to say whether injection of air into a vein by means of a syringe will cause death. It would be unlikely with a hypodermic syringe, which rarely holds more than 2–3 c.c. It would be more likely —even probable—with larger quantities, say 20 c.c. or more, but I think one could never be certain that the method would work in any particular instance.

"(Incidentally, it is difficult to inject into an artery. It would almost certainly have to be a vein.)"

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The idea is extremely ingenious—but, in fact, it looks as though the murderer could make certain of killing the victim only by connecting a bicycle pump with the vein.

## Arsenic as a Food

In another of her books Miss Sayers has a much more plausible method. *Strong Poison*, the novel which introduces *Harriet Vane* —probably the most successful character in detective fiction—has a murder by arsenic poisoning. The victim shared an omelette with the murderer: he died, the murderer survived. Lord Peter established that the murderer had built up an immunity from arsenic. Here is his own (again characteristic) description, together with a medical report.

"Some fellow...found that, whereas liquid arsenic was dealt with by the kidneys and was uncommonly bad for the system, solid arsenic could be given day by day, a little bigger dose each time, so that in time the doings—what an old lady I knew in Norfolk called 'the tubes'—got used to it and could push it along without taking any notice of it, so to speak. I read a book somewhere which said it was all done by leucocytes—those jolly little white corpuscles, don't you know—which sort of got round the stuff and bustled it along so that it couldn't do any harm. At all events, the point is that if you go on taking solid arsenic for a good long time—say a year or so—you establish a what-not, an immunity, and can take six or seven grains at a time without so much as a touch of indi-jaggers.... Well, it occurred to me, don't you see, old horse, that if you'd had the bright idea to immunize yourself first, you could easily have shared a jolly old arsenical omelette with a friend. It would kill him and it wouldn't hurt you."

(J. Y.) "Solid arsenic ($As_2O_3$), unlike soluble arsenic compounds, produces well-marked tolerance if taken in small doses over a long period. It appears that the tolerance (Lord Peter's 'immunity') is due to the fact that the lining cells of the intestine become more resistant and consequently less arsenic is absorbed. I think therefore that it would be quite possible on these lines to eliminate one's friend by sharing an arsenic omelette with him."

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## Hannasyde and the Toothpaste

Miss Georgette Heyer.

One of the wittiest of detective writers, Georgette Heyer, had an ingenious poisoning device in her book: *Behold Here's Poison.* An unpleasant head of a family is found to have been poisoned with nicotine; several relatives with motives had, it appeared, opportunities of poisoning various foods, drinks and medicines which he had taken, but, since nothing of these remained for analysis, the suspicions of Superintendent Hannasyde were pretty widely spread. Shortly afterwards an odd, but by no means well-hated, sister of the victim also died of the same poison. She, however, left an unfinished tube of toothpaste; it was discovered that this had also been used by her brother.

Here are Hannasyde's words, followed by the medical comment:

"The nicotine did not pass through the stomach. It was absorbed through the tissues of the mouth. This is the analyst's report which I've been waiting for. The

medium through which your aunt was poisoned was a tube of toothpaste.... The poison was in all probability injected... by means of a hypodermic syringe, inserted into the bottom end of the tube, and driven up a little way through the paste. The paste at the bottom of the tube is untainted, and it is obvious that the paste at the top end must also have been free from poison."

(J. Y.) "On the whole, the absorptive powers of the 'tissues of the mouth' are not great, as witness the fact that many gargles and mouth washes contain substances which would cause severe symptoms if swallowed. But it has been shown recently that certain drugs are quite readily absorbed in the mouth: in particular, it was found that one drop of nicotine placed on the tongue or throat of a cat killed it within a few minutes. Since as little as two or three drops of nicotine when swallowed will kill a man very rapidly, it is quite possible that a toxic dose would be absorbed from, say, toothpaste in the mouth. In view, however, of its very strong tobacco-like taste and smell, one would have to imagine that the composition of the paste was such as to mask these properties of nicotine."


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### H. M. Nearly Baffled

That most amusing of detectives, Sir Henry Merivale, has one of his best cases in *Red Widow Murders*. Here Carter Dickson gives us a locked, and supposedly deadly room, in which a man sits to kill a family superstition. The door is watched by several people, the windows are barred on the inside; yet he dies. The post mortem shows that he had been poisoned by curare—which, of course, is harmless if swallowed; to be lethal it must be injected into the blood by way of some cut in the skin. No one could have reached the victim, to inflict such a cut. The problem stumped H. M. for some time; but at last he discovered that the victim had had a gum lanced that day, and had received from the murderer a flask containing whiskey and (so he was told) a drug to stop the pain. The flask contained curare. The murderer had to run a risk in taking away the flask when the body was discovered; but for some time no one thought of looking for a flask, since no one was concerned with what he had swallowed. This is how H. M. describes the manner of death:

"I steered myself wrong from the first; I insisted to myself and everybody else that the curare could never have been swallowed, because it wouldn't have hurt Bender.... But what I didn't realize, and what nobody else looked for, was a small puncture in the gum, toward the wisdom teeth, probably, where the gum is so apt to get infected—a puncture made the afternoon of his death. Blood-stream! Of course it poured right into the blood-stream, and killed him quicker than any injection. We look all over his body, and find absolutely no wound by which you could shove in the poison; but how are we ever to spot a little thing like a lanced gum?"

(J. Y.) "Theoretically, it is certainly possible to die when certain poisons, innocuous when swallowed, are absorbed into the blood through a cut. I cannot say how likely it is for someone to have such an amount of curare—an extraordinarily bitter substance—in his mouth that he might be able to absorb the two or three grains which would be needed to kill him."

### Inspector Poole's Mixture

Finally, there is Henry Wade. In his *No Friendly Drop* we have the sudden death of a Lord, one of those county figures whom Wade handles so sympathetically. The murder is a complicated one; it depends, after the manner of *The Mysterious Affair at Styles*, on a combination of substances;

but in this case they are not mixed until they reach the body of the victim. He has taken chloral tablets (containing a non-lethal dose of di-dial) for neuralgia. Then the murderer puts hyoscine in his morning cup of tea. Inspector Poole hears the verdict of the police analyst:

"I found di-dial scattered throughout practically the whole of the digestive tract. . . .In all I estimate there must have been between two and three grains, certainly not more. I should not regard that as, in itself, a lethal dose, especially to a subject who had been taking it for some little time. But there was also present a second poisonous substance, of a different genus but having a somewhat similar hypnotic effect—scolopamine, more generally known, perhaps, as hyoscine. . . . There's not much of this stuff, either, perhaps one forty-eighth of a grain, nearly all in the stomach —nothing like a toxic dose. And that is the interesting part of this case. Here you have two poisonous substances present in the body, neither of them in sufficient quantity to be toxic, but combined—deadly."

(J. Y.) "Certain combinations of drugs are much more potent than their individual properties would lead one to expect. Such synergic or potentiating effects are, for example, seen with chloral and morphine. However, I have not been able to find a definite statement of the synergic effect of hyoscine and dial. Of course, the number of known drugs with an hypnotic action is enormous and the possibilities of combining any two of them is little short of infinite. But hyoscine is a common drug and so are the barbiturates like dial, and I feel that if they had any marked synergic action, I should have come across a reference to it. But what seems important is that I cannot find a reference to a case in which a combination of two such drugs, each in less than the toxic dose, have actually caused death. I feel here too that if the possibility existed, it would be important enough to be included in the standard works on pharmacology and toxicology."

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In this case (as in the artery injection) we have no definite denial that the suggested method could kill its man: but we have a distinct note of doubt. All these five murderers sailed near the wind; all were lucky, in varying degrees, to kill their victims. But they took the risk, and their creators are plausible.

**Volume I, NEW SERIES**

As the Cambridge University Press, in taking over *Discovery*, has decided on a change of format, Vol. XIX will consist of three issues only. Readers wishing for title pages for this volume are asked to apply for them. The new style now begins a new series, and will be numbered Vol. I, NEW SERIES. Title pages for this volume will be available at the end of the year as usual.

# The Paradox of Life and Death

## By C. H. WADDINGTON

*(Dr Waddington is one of the most eminent of the younger embryologists. His branch of science has in recent years produced some of the exciting discoveries in modern biology. These discoveries have suggested many revolutionary ideas in the meaning of such terms as "life" and "death". Dr Waddington describes some of these ideas here.)*

THE life of man, or of any of the higher organisms, is based upon a partial death. In fact, we probably begin life by dying a little. At the moment of conception, when the fertilizing sperm enters the egg cell, the egg-surface undergoes a change. This change initiates the whole subsequent development and leads to the gradual formation of the adult. This process is spoken of as the activation of the egg, and is the fundamental beginning of the individual's life. It is still not exactly understood, but very probably the most important part of the activation is an alteration of the proteins of the egg-surface. And this alteration seems to be from the natural state into the so-called denatured state, which is the normal state of *dead* proteins.

### Growth means a Loss of General Capability

As the egg develops, it becomes more and more complicated, and, from some points of view, it becomes more and more alive. It grows into an embryo with a heart which begins to beat, muscles which move and an intestine which will eventually begin to absorb nourishment. But at the same time as it becomes a little animal and enters on to the activities which constitute its life, other changes are taking place which can only be regarded as a gradual relapse into death. At first every part of the egg is capable of every kind of development. If the egg is cut in half, each half forms a complete animal; in fact the egg develops into identical twins, and in a few animals, such as the armadillo, the egg regularly breaks up into pieces soon after fertilization and each piece grows into a separate individual. This capacity to develop into a complete organism is just the sort of property which one thinks of as one aspect of vitality or life. But it is a very transient one; the egg soon loses its general potentiality for development, and becomes to that extent more "dead". The loss of potentiality takes place gradually. If we consider one small part of the egg, it has at first unlimited capabilities of development; then it becomes restricted to the formation of some large organ or system of organs, such as the nervous system; and later on it becomes restricted again to some more specialized region, such as a particular part of the brain for example. One can describe the process by saying that at the beginning of life each region of the egg has very wide "*potencies*" for the characteristically living process of development, and that as life proceeds it gradually loses these potencies and becomes more "dead".

### Is this only a Play on Words?

This may seem merely a superficial paradox, from which nothing can be deduced and which suggests no novel approach to the problems with which it deals. As long as the paradox is thought of in terms of the vague concepts of life, death, potency, such a criticism is justified. But if we try to consider the problem of development as concretely as possible, and to form working hypotheses about it in material terms, we find again that we have to postulate a paradoxical character for the differentiating

egg, i.e. the egg in the process of development. Differentiation, we find, occurs in a series of steps, each of which can be regarded as the resolution of a *disequilibrium* which is set up between opposing tendencies.

A newly fertilized egg, for instance, is clearly in disequilibrium and cannot remain as it is. We do not know exactly what the opposing tendencies are in this case; we can only see that the egg must change to a more stable state, either by dying out of hand, or by developing through a series of shapes, more stable than the last. Thus the original reason why the egg develops, the basis, if you like, of its livingness, is a state of instability which inevitably diminishes as development proceeds.

### Development in Terms of Present and Future

Consider, again, what is really meant by the word potency which was used above. As we used it, it was a purely descriptive word; a thing had a potency for doing something if later on it actually did that thing. But to say that a certain part of an egg has a potency to become brain does not give any information about what the part is like *now*. It merely tells us something about what it will do in the future. The idea of potency, if it is interpreted like this, is no help in accounting for the causes which bring about development, since for that we require to know the present factors in the tissue which cause it gradually to alter into brain. The recent results of experimental embryology show that the "potency" of each part, just as of the whole egg, is really a state of instability, which, by causing development, must bring about its own disappearance. A piece of an egg which will eventually turn into some region of the brain is at first just like all other parts of the egg and has no special properties corresponding to a potency for brain. After a time, a large part of the egg, including the future brain material, becomes unstable, so that it develops into brain if it is suitably stimulated; if it is stimulated in some other way it becomes something else, skin, for instance. The stimulus is provided by the region which Spemann has called the organizer, and normally it reaches a part of the egg just large enough to cause the formation of a brain of the right size. It is known to be produced by a chemical substance given out by the organizer, and presumably the instability of the reacting tissue must also be chemical in nature. But we do not yet know what chemical systems are involved; all we see is that part of the egg becomes as it were poised between two alternative lines of development and can be shifted into one or the other according to what stimulus it receives from its surroundings. Once the choice has been taken, there is no going back; the instability has disappeared, and the tissue, although it becomes more and more highly differentiated and specialized, has irretrievably lost its original adaptability.

### The same Process in Evolution?

The advance in biological organization which has occurred in evolution probably also depends on a compromise of life with death. We cannot observe the origin of life or the most fundamental happenings of evolution, but must rely on comparison and analogies with the living and dead materials which we can find in the world to-day.

### The First Living Things

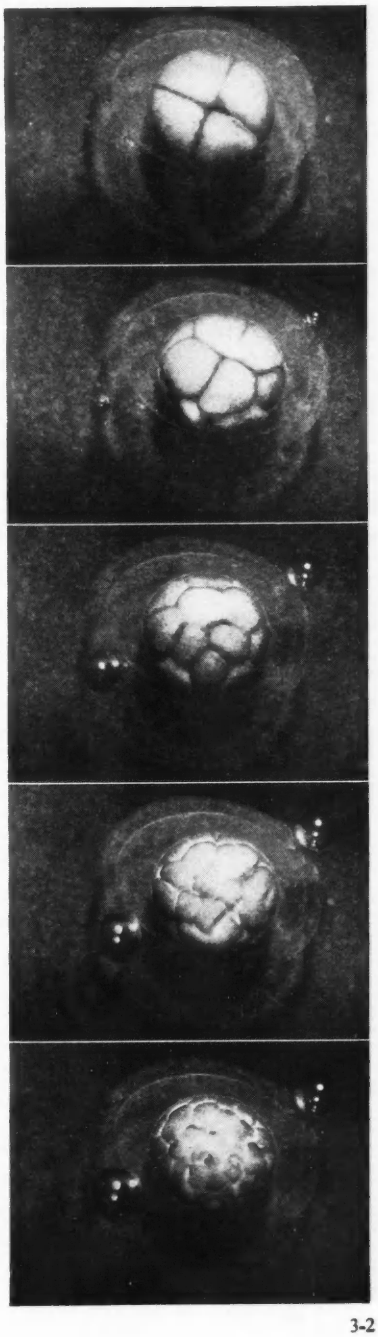
Evolution must have started with the most primitive living things imaginable. The most important property they must have had is a capacity to reproduce themselves. The process of reproduction is perhaps the greatest mystery of biology, but it is one of the most characteristic properties of living things that they can build up out of their surroundings an exact copy of themselves, so that they increase in numbers. Before this power could be evolved, the world must have contained many com-

plicated chemical compounds of carbon, similar to the simpler compounds used by living organisms of to-day. *The essential step in the origin of life was taken when a molecule arose which was self-reproducing and could therefore grow.* The nearest approach to such molecules in the present world are the particles of *viruses*. They are ultra-microscopic, only just larger than the largest ordinary molecules. They only reproduce themselves when they are in a very special environment, namely inside the cells of other living organisms, but they can live without multiplying in many other situations. Probably the original living things were rather like them, at least in size.

If this is even an approximately true picture of the first living particles, it is immediately obvious that all highly evolved organisms have partially lost the fundamental vital power of self-reproduction. Most of the molecules in the body of a higher animal cannot reproduce themselves on their own, but can only increase in numbers when they are part of a whole organism. A molecule of the red pigment of the blood, haemoglobin, has no intrinsic capacity for multiplication, nor, to take an extreme example, has a molecule of calcium phosphate from bone. They only increase and multiply in organisms whose truly living part is capable of synthesizing them.

### The Results of Evolution

If one takes a broad view of the results of evolution, it appears that the increase in complexity of organisms has involved an increase in the proportion of dead material which they contain. The organisms which, judged by their power of reproduction, are *completely living*, are very small, perhaps always of molecular dimensions. Any increase in complexity depends on an



The First Steps. At the very beginning of life the fertilized egg starts to divide into the smaller cells out of which the embryo will be formed. The changes which bring this about are akin to the changes which occur when an animal dies. The photographs show a newt's egg inside its gelatinous capsule.

3-2

increase in size, and this always seems to require that part of the organism becomes "dead" and serves as a supporting skeleton or protective skin for the rest. There are degrees of such "deadness"; a lowly organism such as *Amoeba* has no essential parts which are as dead as bone, while in the highest animals such as man or insects the dead, non-reproducing parts of the body become very large and important.

### Loss of Immortality

We can see the dependence of evolution on death from another angle if we consider the length of life of individual organisms of different kinds. Take a protozoan such as *Amoeba*. Not every molecule of it is alive in the sense that it can reproduce itself on its own; many of the molecules can probably only be formed by the synthetic action of the most fundamentally living elements. But the *Amoeba* as a whole reproduces, and when it does so, it grows in volume for a time and then splits into two. One cannot say that the original *Amoeba* has died; it is still alive as the two daughters into which it has divided. The process of splitting can be repeated indefinitely, and there is no reason why any part of the original *Amoeba* should ever cease to be part of a living organism. In more highly evolved animals, this potential immortality is lost. The body of the animal must die; only a tiny part of it, some of the reproductive cells, will be handed on to form part of the next generation. The complicated and beautifully adjusted body of the animal, which we accept as evidence of the power and achievement of evolution, has only been made possible by compromising with death and relinquishing the pristine immortality of the first and simplest living beings.

### The Completely Living Parts of an Organism

In the last analysis, the only completely living parts of an organism are those elements which are handed on from one generation to the next and which, retaining the power of self-multiplication, control the formation of the adult from the fertilized egg. These elements are the genes contained in the chromosomes. It is interesting to find that, according to the latest estimates, they are of the same order of size as virus particles. Present-day genes and present-day viruses are both products of long evolution, and it is unlikely that they are very like one another. But probably both of them are more like the original self-multiplying molecules than anything else we know of.

The original living particles must have had a property which genes have now; perhaps viruses also possess it. They must have been capable of varying, and then of multiplying the new variant form. If the particles remained perfectly constant and always reproduced themselves perfectly, no change would occur and evolution would be impossible. Here again we see the dependence of evolution on a paradox. Variation, and evolution, can only occur when there is a breakdown of the original constancy and accurate reproduction which we consider to have been the original form of life.

Philosophers have usually been too easily content to accept man as the highest form of life and the evolution which has led up to him as a progress from the simple and lowly to the complex and superior. But the opposite point of view, which has been presented here, cannot be neglected. What is the meaning of this dependence of evolution on death? Is it something to do with the inevitable workings of the Second Law of Thermodynamics? Is some form of tension and compromise essentially included in our ideals of the higher forms of existence? Where does the "death-instinct" of the psychoanalysts come into the picture? There are innumerable such questions; but perhaps very few of them have conclusive or convincing answers. Certainly there is no room to discuss them adequately in a short article like this. In any case, every reader will probably have his own answers to suggest.

# The Truth about the Truth-Drug

By WILLIAM B. PROUDFOOT

(*Mr Proudfoot, B.Sc., B.Pharm., M.P.S., is a lecturer in pharmaceutical chemistry in the Chemical Department of the Dundee Technical College.*)

THE popular imagination has caught on to the idea of the use of a so-called truth-drug as an instrument of terror in dictator-ridden states. Under its influence the victims are supposed to speak the truth, the whole truth, and nothing but the truth in a manner wholly satisfying to the prosecutors. American third degree methods "have nothing on" the truth-drug.

The fact of the matter is that there is no such drug. Nevertheless there is a drug, which, administered by injection, causes certain types of patient to become for a short space of time voluble and sometimes disconcertingly frank and truthful. It is called Evipan.

The truth about the truth-drug lies in the story of Evipan; for it is the only drug whose action in any way approaches the function of this hypothetical specific for unveracity.

Evipan is an anaesthetic, a general anaesthetic like ether or chloroform in that the patient under its influence loses consciousness completely. Unlike chloroform or ether, however, Evipan is not inhaled as a gas or vapour. It is injected in solution direct into the blood-stream, usually via a vein in the fore-arm.

Two chemists, Kropp and Taub, discovered Evipan in 1932 while carrying out researches in the laboratories of the well-known firm of manufacturing chemists, Bayers of London. It rejoices in the name of N-methyl-C-C-cyclo-hexenyl-methyl-barbiturate, and is chemically related to the group of hypnotic chemicals, to which the better-known drug barbitone or veronal belongs.

As an anaesthetic Evipan is very safe. The patient falls asleep during the course of the injection, often within the first minute. By the end of the second minute complete anaesthesia is established, and the operation can be started right away.

It was while using it as an anaesthetic for minor surgical operations that an Edinburgh doctor began to take notes of the reactions of the patient during the period immediately preceding the induction of sleep. As already indicated certain patients entered into a confused loquacious condition. It was found that this talkative period could be prolonged at will by manipulating the rate of the injection. In this respect Evipan is unique. In this respect might Evipan be regarded as something of a truth-drug.

The general drift of the patient's unconscious remarks was either disturbingly critical or surprisingly confessionary. Often it was a strange mixture of both. A staid business man would confess to a secret admiration of his pretty typist, and then go on to candid observations on the inefficiency of his legal, or even his medical, advisers.

On awakening out of the anaesthesia there is, with certain types of patient, a similar excitable condition, characterized by a lack of orientation and a tendency to talk too much. The duration of this period of course cannot be prolonged by further injection on account of the danger of overdosage. It was to this period, however, that attention was directed to test the truth-drug nature of Evipan.

Various normal people have undergone experimental injections and have been subjected to "third degree" questioning immediately on showing signs of recovering from the anaesthesia. There is no doubt that in many cases the mind may be so befuddled that it is incapable of the mental effort of framing a denial to accusations, false or otherwise.

In this respect, again, Evipan is the truth-

drug, or at least the nearest thing we have got to it.

The drug has found some use in psycho-analysis. It has helped the psycho-analyst to arrive at the story of some repression, hidden too deep in the unconscious for excavation by ordinary means.

As regards the use of Evipan in criminal investigation, the fact of the matter is there is no evidence. It has not been used for that purpose in this country. A study of its properties indicates that it is extremely unlikely that the amazing confessions of certain political prisoners in recent trials in Moscow were made under the influence of Evipan.

Roughly the position is this. There is on the one hand the truth-drug of popular fancy. The requirements of such a drug are that its action is prolonged, lasting several hours, or days even, and that under its influence the patient, or prisoner, has his mind and will so separated from each other that any desired confession can be extracted from him easily. Such a drug is not known in British medicine, and responsible opinion is inclined to regard rumours as to its discovery and use in other countries as merely fanciful.

On the other hand there are the comparatively few notes on a particular use of the anaesthetic Evipan, under the influence of which in certain cases the unconscious mind, with its store of repressed facts and opinions, is given unexpected scope. Connected with this is the possibility of bullying a patient into some confession during the semi-conscious state of recovering from the anaesthesia. The medical evidence in this respect is negligible as compared with the literature on the normal uses of Evipan as an anaesthetic for surgical operations.

These facts are perhaps not very sensational or exciting; but in connexion with the truth-drug is it not as well to know the truth?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# *The Cavendish Laboratory To-day*

By S. DEVONS

IN 1874, in the academic surroundings of an ancient University but in the wider setting of what was then the leading industrial country of the world, the Cavendish Laboratory began a career which has since become a considerable and integral part of the development of physical science. The dual nature of the discoveries and advances for which the Laboratory has been responsible has reflected itself in the fecundity and nature of these discoveries. While the investigations carried out have often been of a fundamental, theoretical or very academic type, they have also been proved, usually not very long afterwards, to have a great value in both industrial application and in advancing the technical equipment needed for scientific investigation itself. In the technical equipment of the Cavendish Laboratory to-day, perhaps more than anywhere else, one can trace the influence of the early investigations carried out in this same laboratory, which at that time had little more than an academic significance.

## The Earliest Years

During its earliest years, under the professorships of Clerk Maxwell and Lord Rayleigh, the main attention of the workers in the laboratory was directed towards problems of classical physics such as exact determinations of the electrical constants. This work, though quite different from the type of research most frequently carried out at the present day in the laboratory, nevertheless forms an indispensable basis for the work which came afterwards. With the completion of this phase, a new era in physical discovery began. New properties of matter were discovered, and the great experiments of the twenty years following were more concerned with new effects and new atomic properties of matter than with exact measurement. In the identification of the nature and fundamental importance of the electron in the structure of matter, one of the most important and far-reaching advances of the period 1885–1905, the Cavendish Laboratory under the leadership of J. J. Thomson played a leading role.

The Cavendish from the street.

## Rutherford

These, and the later investigations in connection with the detection and investigation of atomic particles of matter, have become at the present day the alphabet of physical research and especially of the particular researches of the present-day Cavendish Laboratory.

In the field of nuclear physics, science generally and especially the Cavendish Laboratory owe a great deal to the late Professor of the Laboratory, Lord Rutherford. In about 1900 Rutherford began a series of researches which led to such great discoveries as the explanation of radioactive disintegration, the nuclear model of the atom; and in 1919, by means of the particles emitted from radioactive substances, Rutherford first demonstrated that atomic nuclei could be broken up in this manner. These experiments are the direct precursors of the present-day research. During this period, as in the time of Sir J. J. Thomson, new properties of matter in the atomic form were being investigated, and accurate measurement was not always possible or significant. The apparatus used in this period was often therefore—by present-day standards—comparatively simple and sometimes rather crude. This period has often been referred to as the period of string and sealing wax.

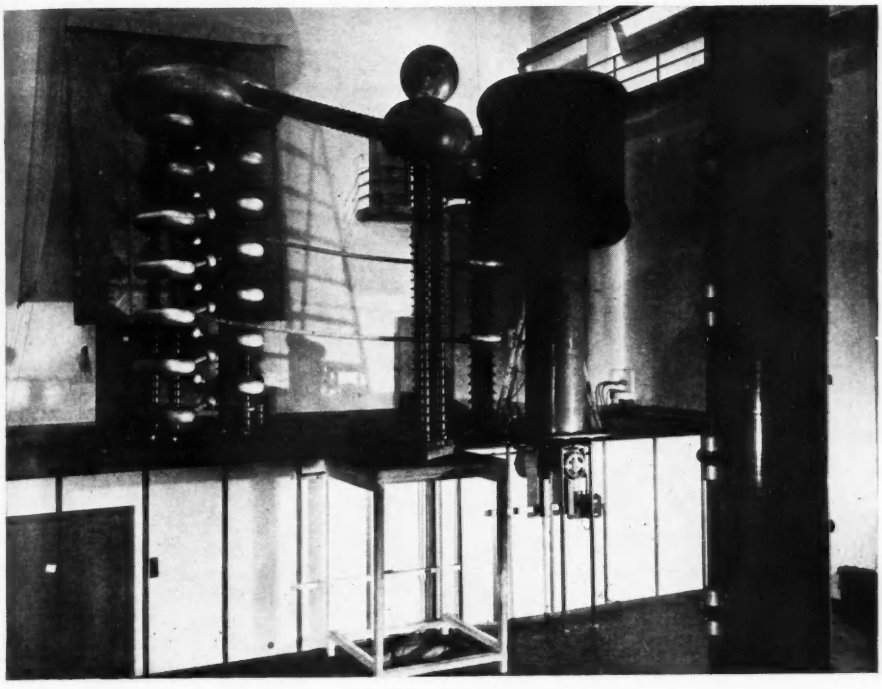
### Splitting the Atom

But at the present day the situation is quite otherwise. Enormous technical equipment is involved in modern research in nuclear physics, and in addition exact measurement is becoming important in fields where not many years ago simple qualitative experiments were being made. Among the first of these experiments requiring large-scale technical equipment were the well-known achievements of Cockroft and Walton, who in 1932 in the Cavendish Laboratory were able for the first time to disintegrate atomic nuclei by entirely artificial means. Since that date an enormous amount of research has been directed towards developing methods for producing fast particles—similar to those emitted naturally by radium and other radioactive substances—for the purpose of artificially disintegrating atomic nuclei. At the present time a number of methods are available for producing these particles of enormous speeds in very large numbers, corresponding in fact to several thousands of times the number of particles that were obtainable naturally from radium and similar substances.

Side by side with this great development of the technique of producing very fast particles in large numbers, there has been a corresponding development in the methods by which these minute particles—they are only tiny fractions of an atom, and it is only by virtue of their high speed that, as a rule, they can be detected at all—can be detected, examined or counted. Here the advances have been in several directions. With the growing use of larger and larger numbers of particles, it has been found necessary to devise methods capable of registering and counting these particles very rapidly. For counting these particles, the methods used at the present time are almost entirely electrical; and this electrical equipment, made possible by the great advances in the manufacture of wireless valves and other electrical apparatus, is a recurring feature of a modern nuclear physics laboratory.

### How to Count Particles

The most widely used present-day method of detecting and counting these high speed charged particles is briefly as follows. The particle enters, through a suitable opening, a small electrical condenser which is kept permanently charged to a potential of a few hundred volts. The particle in its passage through the condenser causes it to be temporarily (the process lasts less than one millionth of a second) partially discharged. The electrical disturbance thus brought about is communicated to the grid of a thermionic valve where it causes a temporary change in the current flowing in the valve. This disturbance is further amplified (in the same way as the electrical impulses entering a wireless aerial are amplified in an ordinary radio set, until they are sufficient to produce audible noises) until the total amplification is about one million or more. The large impulses so produced are then, as a rule, passed into an electric network so that every eighth or tenth impulse is recorded by some mechanically moving dial.



High Voltage Equipment. See description on p. 42.

By recording mechanically only the eighth or tenth particles much higher rates of counting are possible than if every particle is recorded in this way. A modern high speed valve counter of this type is capable of counting particles arriving at rates up to 10,000 a minute! Research is still being directed towards improving this type of counter, and from a glance at present-day equipment of the Cavendish Laboratory one would certainly conclude that the thermionic valve has come to stay in the field of nuclear physics.

The cathode-ray oscillograph is another piece of apparatus that is becoming increasingly prominent in a nuclear physics laboratory. This is used in conjunction with the amplifier in order to sort out the sometimes jumbled signals that the amplifier gives out. It at once recalls the early electron experiments of J. J. Thomson, and it emphasizes the advances that have been achieved in the last forty years. What was then a fundamental and "academic" experiment has become a piece of laboratory equipment almost as familiar as an ammeter or as a thermometer.

### The "Cloud-Chamber"

There is another quite different method in use to-day for the study of these particles of matter, known as the "cloud-chamber" method, a method of investigation originated by C. T. R. Wilson and developed by Blackett, both workers in the Laboratory. In this method the actual track of the particle is made visible, owing to a property of charged particles which causes water vapour to condense. The fast moving

particles in their passage through the "cloud-chamber" leave a train of charged (or ionized) molecules in their trail, and these cause water vapour present in the chamber to condense along the track. Such tracks are photographed and then form permanent records. This method has the advantage that it provides much fuller information about the particles than is usually given by the electrical recording method. On the other hand a "cloud-chamber" is only sensitive to particles for a small fraction of a second at a time (i.e. during one "expansion"), and between each such period it is necessary to reset the chamber afresh. This latter process is being made more and more automatic in the modern laboratory. Another recent advance is to combine the two methods of detection, so that the electrical recording of an arriving particle sets a "cloud-chamber" in operation and enables the track of the same particle to be photographed in the "cloud-chamber".

### High Voltage Equipment

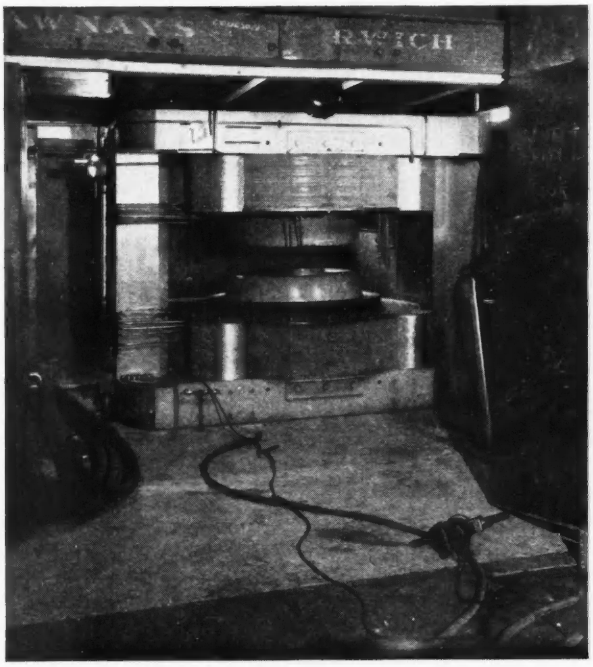
There are two main methods in use for producing fast particles used in the disintegration of atomic nuclei, each involving considerable technical equipment. One of these is in principle the same as that first used successfully to disintegrate atomic nuclei in 1932 by Cockroft and Walton. The particles which are originally moving comparatively slowly are accelerated through a potential difference of the order of a million volts. Great developments in producing such large potentials have been made in the past few years, and high voltage equipment of the present day is a good deal more reliable than the early apparatus. Investigations are being carried out in the laboratory with a view to constructing an apparatus capable of producing two million volt accelerated particles. The high voltage equipment now in use in the Cavendish is housed in a large laboratory specially built for this purpose. With such high voltages as a million volts special care in construction is necessary in order to avoid the occurrence of spark discharges from the high voltage parts to neighbouring walls and other objects several feet away.

The fast particles produced with this apparatus are used to bombard the desired target and any disintegration of the nuclei is shown up by the emission of fast particles (similar to those used to bombard the target) which can be detected in either of the ways described. Sometimes the resulting atom left after a nuclear disintegration is not an ordinary stable atom but one which is radioactive. Such artificially produced radioactive substances go on emitting their radiation, consisting of fast moving electrons, for some time after they have been produced by bombardment with the high voltage particles. The radiation gradually dies away as the radioactive nuclei change into stable ones. A great deal of research which is going on at the present day is concerned with examining the exact nature of the particles emitted in particular disintegrations, and measuring the speeds with which these particles are emitted in the reactions. Such information is the means by which the structure of the atomic nucleus can be studied, and mechanism of nuclear disintegration understood.

### The Cyclotron

The other method used for producing beams of fast particles for nuclear disintegration work depends on quite different principles. No very high voltages are necessary but particles corresponding to a high voltage apparatus of about twelve million volts can be produced. A source of comparatively slowly moving particles is in the centre of a hollow circular disc-shaped box. The box is divided into two halves, and is placed between the poles of an enormous electromagnet. The two halves of the box are at a potential difference so that the charged particles are accelerated across the space between the two halves of the box. The presence of the large magnetic field causes the path of the particles to be circular instead of straight. The particles are turned round so that they cross the gap between

the two halves of the box again, but this time in the opposite direction. The potential difference between the halves of the box is not constant but alternating at such a frequency that when the particles cross the gap the second time the potential is exactly reversed. Since the direction of crossing the gap is also reversed the particles will be accelerated in exactly the same direction each time the gap is crossed. The particles thus spiral out from the centre, increasing their speed by the same increment each time they cross the gap between the two halves of the box, until they finally emerge from the box, more or less tangentially, with very high speeds.



The Cyclotron.

This type of apparatus, known as the cyclotron, was first successfully constructed in the U.S.A. by Lawrence about five years ago. A similar apparatus is at present nearing completion in the Cavendish Laboratory. It provides much faster particles than the high voltage method, and thereby opens new regions for research in the field of nuclear structure.

Along with the investigations with these two main methods of nuclear disintegration, a number of researches on allied problems are also in progress. A particularly interesting type of research is concerned with testing whether in certain cases two or more particles resulting from a nuclear disintegration (natural or artificial) are emitted simultaneously or not. Electrical methods are able to tell whether two particles are recorded within a thousandth of a second or so of each other. Studies are also being made of the radiation from the artificially produced radioactive substances already mentioned, and also of processes in which the bombarding particles do not disintegrate the bombarded target but are simply scattered by the atomic nuclei of the target.

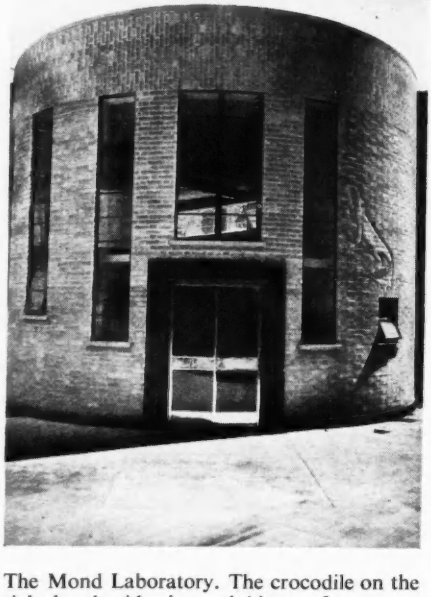
### The Upper Atmosphere

Researches in nuclear physics are, however, not the only investigations carried out in the Cavendish Laboratory to-day. A small group of experimenters headed by Prof. Appleton are investigating the mechanism of the transmission of radio waves in the upper regions of the earth's atmosphere. Such experiments provide a great deal of information about the nature and condition of the gases in these regions of the atmosphere. Here again the importance of the thermionic valve and the cathode-ray oscillograph in modern physics research is emphasized.

Closely associated with the Cavendish Laboratory are the Mond Laboratory for

low temperature and magnetic investigations, and the Crystallographic Laboratory. In the Mond Laboratory researches into the magnetic and electrical behaviour of matter at liquid helium temperatures are being carried out; and also new methods of producing very low temperatures, of the order of one-hundredth of a degree absolute, are being investigated. In the Crystallographic Laboratory a good deal of important research is being made into the crystal structure of organic compounds such as crystal proteins and viruses, and into the nature and structure of liquid crystals generally.

Quite recently Prof. W. L. Bragg has been appointed to the Cavendish Professorship of Physics as successor to the late Lord Rutherford. Prof. Bragg is well known for his achievements in the field of crystal physics. In the not very distant future the name of the Cavendish Laboratory may well be linked up with this branch of science, a science which is not, at the present day, primarily associated with the name of the Laboratory.



The Mond Laboratory. The crocodile on the right-hand side is a joking reference to Rutherford's nickname.

# New Developments in Colour Photography

## By M. WIEDLING

*(Entirely new standards of direct photography in natural colours have recently been established by the perfecting of two different but related films marketed in the last two years. This article describes the general history of colour photography and the principles on which the new method depends. An example of a landscape photographed in full colours is included as a plate in this number of* Discovery.)

SOME 2000 different processes have been proposed for obtaining colour photographs. Patent literature on inventions relating to colour photography would fill a library. In fact it is doubtful whether any other subject has lured so many people to inventing. Colour companies have been founded and liquidated. Newspapers have repeatedly announced that the problem of colour photography (and a highly complex set of problems it is) has been solved by someone or other; and yet in the course of a hundred years it has not been possible to popularize colour photography, in spite of the genuine desire of every photographer, amateur and professional, to photograph objects in their natural colours.

Colour photography, to be as satisfactory to the user as ordinary black-and-white photography, should consist essentially of two main stages—the taking of the photograph on a film or plate, and the making of a colour print therefrom on paper. It is the second half of this ideal procedure which still offers great difficulties. Of the colour-printing processes in existence none is anything like so straightforward an affair as the making of a print in monochrome. But the one thing that the ordinary photographer must have, especially he who only takes his pictures during his holidays, is a *print*. There are firms who will do this for him in colour, but the results are still costly and doubtful. Colour photography, for these reasons, could hardly become popular with the great army of snapshotters, even though various more or less satisfactory colour films have existed for some years.

It seems a pity to be deterred from taking colour photographs simply because no quick colour-printing process exists as yet. The best paper-printing process conceivable will not give results as true to life as projection gives, and projection is entirely possible now. Small, efficient projection apparatus, with an electric bulb as the safe source of light, has replaced that old impediment, the magic lantern, and anyone can now project at home pictures in natural colours more beautiful than any print will ever be. Colour work of this kind has received an enormous impetus by the advent of two new colour processes—the Kodachrome and the New Agfacolour—in the years 1936 and 1937 respectively. Both films work on the subtractive colour principle, and possess a clearness and transparency not previously achieved with any other process and certainly not with any plates and films based on the additive colour method.

It may be as well to remind readers at this point what the terms "additive" and "subtractive" define as applied to colour processes.

In 1855 Clerk Maxwell proved that by taking three separate photographs of an object through three primary filters, red, green and blue, and projecting the three photographs (each through its appointed filter), on top of one another, an image in full natural colour would result. This principle of adding together the three primary colours to obtain white or any mixed colour is called the additive process. The classical demonstration of the prin-

ciple is the projection of discs of red, green and blue light so that they mutually intersect: where all three colours superimpose, white light results, and where only two colours superimpose, the following mixed colours result: red + blue = magenta; blue + green = blue-green; red + green = yellow.

The subtractive colour principle can also be demonstrated by projection; only one projector is used, which throws a white field on the screen. A yellow filter brought into the path of the rays will, as everyone knows, absorb the blue and violet (thereby upsetting the balance of white—white light being a mixture of all colours) but will allow the mixture of the rest (which makes yellow) to pass. We thus have a yellow field on the projection screen. If now a blue-green filter is interposed, it will absorb the red part of the yellow mixture of light, and the resulting field will be green. A third filter, this time red, will absorb the green and then no light will pass at all. Every filter subtracts a certain colour portion from the white light.

Briefly, then, the additive method produces white (or the mixed colours) by adding together the three primary colours in the proper proportions, the subtractive process starts with white light and obtains the mixed colours by subtracting from it the complementary colours.

Photographic processes of the additive type may require three separate photographs as suggested by Clerk Maxwell, or they may consist of emulsions which embody (irregular) colour grain or (regular) mosaic. Although these granular or mosaic processes make possible colour photographs with a single exposure, and even snapshots, the fact that the three primary colours are mixed to give white, and the presence of a silver image, make it obvious that transparency will be in some degree impaired. The picture thus obtained in colour generally lacks the brilliancy and transparency necessary for the making of good reproductions, whether by a colour-printing process of the photographic type, or a letterpress-printing process for book illustrations. In point of fact this difficulty of reproduction is the most serious drawback of any additive process, especially if, as suggested above, the ultimate aim of any colour process is to be the successful production of colour prints.

The two new colour films on the subtractive principle are not afflicted by any of these shortcomings. In fact, with two such excellent methods available, it is only a matter of time before paper prints will also become available to the larger public.

Both films have, on a single celluloid base, three layers of emulsion one on top of the other and each sensitized to only one primary colour; the top layer being sensitized to blue, there is a gelatine layer dyed yellow between this and the next layer of emulsion to prevent the blue rays from affecting the two other emulsions. The medium layer is sensitized only to green and the lowermost is sensitized to red. No lens filter is required for normal photographic purposes. But whilst with Kodachrome film the colour for each layer in turn is entirely produced by the use of special dye-coupling developers, which couple the required complementary colours of yellow (to the blue layer), magenta (to the green layer) and blue-green (to the red layer), the three layers of emulsion in New Agfacolour film contain from the outset a certain amount of dye-coupler for these complementary colours. The total thickness of this triple emulsion with intermediate gelatine layers does not exceed one-thousandth of an inch, and it is obvious that extreme accuracy is essential in the coating process, since any variation in thickness will at once produce faulty colour rendering. The process of coating the three individual layers absolutely evenly is not easy, and that is why, for the time being, these films are only available in substandard (8 and 16 mm. films) and standard (35 mm.) films.

Since with both Kodachrome and New Agfacolour the silver grain is entirely removed from the emulsion layers during the processing, there remains nothing but a grainless and screenless dye image of crystal

transparency, ideally suitable not only for screen projection, but also for reproduction by printing processes. But none of these developing processes can be carried out by the photographer himself: the various stages are too complicated. The exposed film has to be returned to the manufacturers, who have included the cost of processing in the purchase price of the raw film.

It is not possible here to give a full account of the complex operations in processing. The new films still use the fundamental principle on which almost all colour work is based, that is to say they still depend on the physiological fact that the full range of natural colours can be imitated for the human eye by the use of no more than three colours in various degrees of combination. Where they differ from the other continuous-tone processes is in the manipulation of the three records. The three photographs are exposed, developed, reversed *in situ* and without mechanical separation; and yet the film is so contrived that the separate emulsions register separate primaries, and the processing is so contrived that, in the final result, each emulsion has had individual developing, reversing, and dyeing. The whole film is first subjected to development, reversal and a single dyeing, though the results of this first stage are only wanted in the emulsion nearest the celluloid base. Therefore, after drying the film, the physical and chemical conditions are adjusted so that only two layers are affected by the next process; the two layers in fact receiving treatment of which the results are ultimately only retained by the middle layer. The top layer alone is treated next (the results of treatment being stopped from the second and third layers by control of physical conditions). Finally the silver is cleared from the whole film, leaving three transparent dye-images—in perfect register, since, from exposure onwards, they have never been moved in relation to each other.

It is an amazing triumph of technological precision—to superimpose five specific and different gelatine coatings, of which the three alternates are silver salt emulsions of exactly standardized, different, and yet balanced qualities of sensitiveness, and then, when these mechanical and chemical niceties have been successfully achieved, to devise a series of baths and dryings such that each of the three layers shall receive its appropriate and different chemical treatment, and every operation, from first to last, be carried out with a precision that does not vary from a rigid standard in any measurable degree.

So-called "control" in processing is, of course, impossible. The film can only register exactly the quantity of light and colour admitted by the shutter. Exact exposure is therefore essential, there being very little latitude.

Kodachrome and New Agfacolour material are made by a continuous process and are only to be had in cinema-film sizes at present. Those who are not interested in cine-photography but want still photographs in colour are therefore limited to cameras, such as the Leica, which use standard cine film. These miniature cameras and lenses are, however, nowadays made with such precision that the small size of the original transparency is no serious drawback. The absence of silver means that there is no grain in the transparency, and enlargement up to almost any scale is possible with little or no loss of detail. Within these limits colour photography for every man is a solved problem. What attractive results can be obtained can be judged from the picture in colour in this number of *Discovery*. This is a Leica photograph on New Agfacolour film. It loses inevitably in the method of half-tone reproduction necessarily employed.

# How Water Can Kill Fishes

## By E. H. F. BALDWIN

*(Dr Baldwin is a Fellow of St John's College, Cambridge; he has done much research on biochemical problems, and is also well known through his text-book* Comparative Biochemistry. *In this article he discusses the puzzling and interesting fact that fresh-water fishes die in salt water, and vice versa.)*

VERY high tides, together with exceptionally rough weather, recently caused a large area on the coast of Norfolk to become flooded with sea water. Shortly afterwards thousands of fishes in Horsey Mere were found to be dead or dying. Cases of this kind have been described before, and they set a problem which has interested biologists for many years. Certain fishes are as much at home in sea water as they are in the fresh water of the rivers, and eels, for example, spend part of their time in the sea and part in fresh water. They hatch out somewhere in mid-Atlantic, and set off almost at once on a long journey towards fresh water. In the spring countless numbers of the young eels make their way into certain rivers, notably the Severn, and are caught by the million, for the "elvers", as the young eels are called, are regarded as a great delicacy by the inhabitants of the Severn valley. These elvers remain in the rivers, feeding and growing until they reach maturity, and then set off again to deposit their eggs on the oceanic spawning grounds.

* * * *

This is an exceptional case however. The vast majority of fresh-water fishes die if put into sea water, while marine fishes perish if they are placed in fresh water, and the reason for this is an interesting one. Like that of all other animals, the blood of fishes contains a mixture of salts—the same salts as are present in sea water, but in slightly different proportions—and the actual concentration of these salts in the blood is a matter of vital importance. Any variation of this concentration in any animal is a serious affair, and if such variations become appreciable they mean only one thing, disablement and death. Miners, stokers and others whose employment compels them to work for long periods at high temperatures, sometimes experience the acutely distressing symptoms of "miner's cramp", which is due to slight disturbances in the salt content of their blood. Such men naturally sweat profusely while working and become exceedingly thirsty. If they quench their thirst by drinking ordinary tap water, cramp is likely to develop, the reason being that they lose both water and salts in the sweat, and if only water is subsequently replaced, the blood salts become slightly diluted. Curiously enough the men usually prefer to take salt drinks such as diluted brine or salted beer, which make good the loss of salts as well as that of water, and so prevent the onset of the cramp.

* * * *

Even very slight changes in the salt content of the blood are followed, then, by impaired efficiency of the machinery of the body, and in consequence all kinds of animals must be able to control the salt content of their blood in some way. In the case of fishes, the blood normally contains about one-third the amount of salts present in sea water, so that marine fishes live in a medium which contains roughly three times as much salts as their own blood, while fresh-water fishes inhabit a medium which contains very little salts

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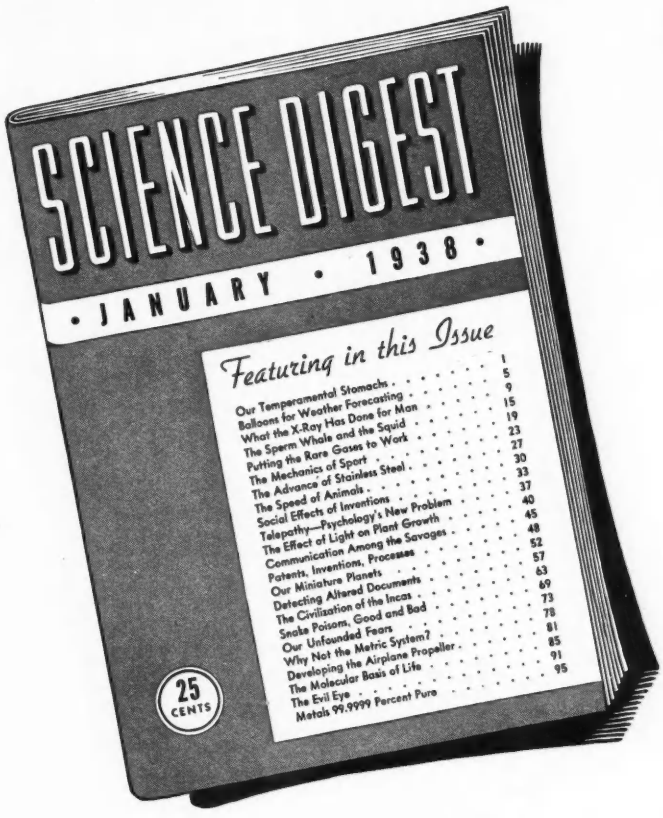
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at all. Now these facts would present no problem at all if the fishes could live completely insulated, as it were, from the surrounding water. But since they have to obtain oxygen from their environment in order to keep alive at all, and since it is the blood which has to carry this oxygen to the various organs and tissues which require it, the blood itself has to be brought very close indeed to the water from which the oxygen is to be obtained. This happens in the gills, and here the blood is separated from the water by nothing but a membrane about one thousandth of an inch in thickness. Thin though it is, this membrane has properties which are of the greatest importance from the point of view of the fish.

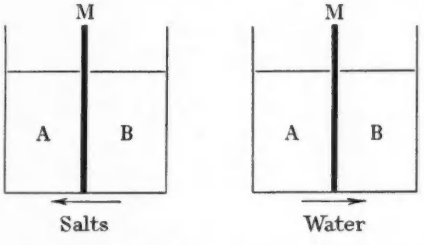


Fig. 1. Two salt solutions *A* and *B*, of which *B* contains more salts than *A*, are separated by a membrane *M*. If salts can pass through *M* they will do so from *B* to *A* as shown in the left-hand diagram, until the concentrations of salts are equal on both sides of the membrane. If *M* allows water to pass but holds back salts, water will pass from *A* to *B* until the concentrations of salts—i.e. the amount of salts per unit volume of solution—are the same on both sides. [This would mean that the level of *B* would rise, and this would go on until the difference in the levels of *A* and *B* was great enough to balance the force tending to force more water across the membrane.]

Let us suppose that we have two salt solutions, *A* and *B*, the first containing very little salts and the second being comparatively rich in these substances, and suppose moreover that they are separated only by a thin membrane, *M*. This system is illustrated in Fig. 1. If the membrane is so dense that neither salts nor water can pass through it, nothing will happen. If, on the other hand, salts are able to pass through, they will do so, passing from the stronger of the two solutions into the weaker, i.e. from *B* to *A*, until the salt concentration is the same in both. In the case of the fish, this would correspond to a loss of salts from the blood to the surrounding water, and we have already seen that such a loss would inevitably lead to the death of the fish. In actual fact, however, the gill membrane is dense enough to prevent any loss of salts from the blood in spite of its extreme thinness, but nevertheless it is permeable to water. Apparently it has not been found possible for animals to develop membranes which will allow oxygen to pass through freely and yet be completely waterproof. If we turn again to our model system it is possible to see what this means to the fish.

The membrane, which is not waterproof in spite of its impermeability to salts, separates two media containing different amounts of salts. Now it is a general principle in nature that things always tend to distribute themselves as uniformly as possible, and water must therefore pass through the membrane from the weaker to the stronger of the two solutions, i.e. from *A* to *B* in the model. The rate at which this happens will, of course, depend upon the magnitude of the difference between the two salt concentrations. This process will go on until both solutions contain the same proportion of salts, and only then, when the uniformity of distribution which nature always aims for has been reached, the passage of water will cease.

* * * *

Applying these ideas to the case of a fresh-water fish, we see that, since the blood is rich in salts as compared with the surrounding water, and since the gill membrane cannot keep water out, there must be a continuous flow of water across the membrane and into the blood. In other words the blood of the fresh-water fish is being slowly diluted all the time. Yet we know

that the concentration of the blood salts is kept at a very constant level, as indeed it must be if the fish is to remain alive and healthy. How is this possible in the face of a continuous inward leakage of water from outside?

In point of fact the fish possesses very efficient kidneys which, like our own, are capable of excreting unwanted water from the body, and it is by means of these that the incoming water is got rid of as fast as it enters, so that the constancy of salt content which is so essential for continued health and efficiency is duly preserved. Fresh-water fishes therefore live in the ever-present peril of death by flooding, though in the ordinary way they can combat this by using their kidneys as one uses the pumps of a leaky boat. The kidneys, like a ship's pumps, cannot work at more than a limited rate, so that if for some reason the rate of entry of water should increase, the kidneys will be hard put to it to dispose of the water fast enough. Apart from the gills, the body surface is covered with a scaly waterproof coat so that there is normally no influx of water except through the gills themselves. But if the waterproof coating is damaged as the result of a fight or by being scraped against a rough surface of some kind, water begins to leak into the body across the damaged area as well as through the gills, and if the extra influx is at all large the kidneys will be unable to cope with the situation fast enough, so that the fish will swell up and die. This is a very common cause of death in aquarium pets.

* * * *

Ordinarily, then, the fresh-water fish can compensate for the water which enters it from the outside. But suppose that the external fresh water is replaced by a solution which is rather richer in salts. The result will be that since the difference between the salt contents of the solutions on either side of the gill membrane is smaller than usual, the force tending to drive water into the fish will also be smaller than usual, and water will enter proportionately more slowly. This could presumably be allowed for by making the kidney work more slowly, so that the rates at which water enters the body and is removed from it are still exactly balanced. From this point of view there is no obvious reason why a fresh-water fish should not be able to survive even in water which contains as much salts as its own blood, for now no water would enter at all and the kidney need do nothing. But the kidney has other work to do. It is by way

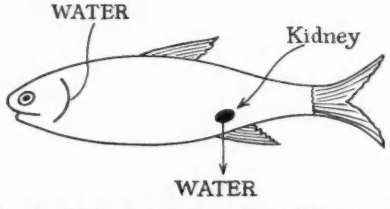


Fig. 2. Water enters the body of fresh-water fishes through the gill membranes, but by excreting it as fast as it enters the fish avoids dangerous changes in the concentration of the salts of the blood.

of this organ that various poisonous impurities are removed from the blood, and these, if not removed, would lead to death from blood poisoning, or toxaemia. A certain amount of water is always necessary if these impurities are to be washed away, so that if the influx of water is cut down to too low a level by putting the fish into too strong a solution of salts, the animal will die because the poisonous waste products of its own vital processes cannot be got rid of.

* * * *

This would happen if the fish were placed in a mixture of about two parts of fresh water with one of sea water, for this mixture contains about the same amount of salts as the blood itself. If the water were made even more concentrated than this, the flow of water across the gill membrane would not only be stopped but actually reversed in direction; hence, instead of receiving water from its environment, the fish would now actually lose water to the

environment. This is the position which the marine fishes have to face, but the way in which they solve the problem must be left to another article. In the case of the fresh-water fishes it is clear that the addition of any considerable amounts of salt water to the fresh can only mean death, either from toxaemia or from actual loss of water from the body. There can be little doubt that the wholesale slaughter of fishes in Horsey Mere must have been due to the admixture of large amounts of salt water with the relatively fresh water of the mere, for, in addition to any sea water which may have passed directly into the mere, many thousands of gallons of salt water must have drained off the flooded fields by way of the streams and ditches and into the mere itself, on its way back to the ocean.

# Reviews

*(A few selected books will be reviewed at length in this section of* Discovery. *We shall also include shorter notes on other books.)*

## The New Vision of Man

*("The New Vision of Man", by F. S. Marvin. Allen and Unwin, 5s.)*

MR MARVIN has made a brave attempt to connect the rise of man from the animals with the development of the vision of humanity. His thesis is that, just as mind differentiated man from animals, and mind found new technique for conquering the earth, so mind inevitably went on to abstraction, and finally moved nearer to the concept of humanity as a whole. His account of the rise of man is one of the most convincing I have seen—at any rate of those written for a wide public. As for his larger view, the development of the idea of humanity, he has somehow made it sound inevitable, which is a considerable and necessary feat.

But such a work invites a lot of criticism, since it touches on most of the disputed questions. Mr Marvin has sometimes disarmed this criticism by the use of an involved and ambiguous style, which makes it slightly difficult to know what he is driving at. It is a pity that the venture into philosophy should so often induce writers into vagueness of style. Mr Marvin is specially vague when he gets on to Beauty. (But what a lot of vague stuff has been written about Beauty during the ages!) It appears from close study that he has got on to the right lines—the connexion of aesthetics with both the mind and the body. We can have intellectual drives as well as sensual drives. Most of our drives have a bit of both; the aesthetic drive

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is that in which both kinds are present in our consciousness, in some kind of synthesis.

That, however, is incidental. What is more important is the assumption that, since the general development of man appears to be good, all the stages must therefore be right. The Roman Empire, for example, is justified. This sort of view seems to be unscientific, although scientific method can, if we are not careful, lead us into it. We find things out, deliberately if we are scientists, unconsciously if we are not, by the method of trial and error. That is what, according to Mr Marvin's admirable main thesis, humanity has been doing with itself. But it is wrong (though easy) to argue that, as we are proceeding by trial and error, the errors must therefore be right. The essential thing about an error is that it is wrong. Humanity has made several errors. The Chinese civilization was too conservative. The Indian was too mystic. The Greek was too drawing-room. The Roman was too materialistic. Ours may fail for the absurd reason that the "nation", that artificial entity which we invented as a small approximation to humanity, may easily appear to be the whole of humanity to us.

I am afraid Mr Marvin has not allowed for that drive which runs against all he hopes for. I mean the universal human desire to submit to a father, or father-substitute. In the early days of man, in Egypt and Babylonia—before abstract thought had grappled with "humanitas"—men did this inevitably and naturally. The Greeks, remote as they were in so many ways from reality, did grasp the idea of responsibility, and they had an urge for individual liberty (for themselves, not for their slaves). In the Roman Empire this new (and, to Mr Marvin, essential) drive was outweighted by the desire to submit to a father. The main obstacle in the way of a united world to-day is this same desire. "Let us have a king, like other people", the Israelites said to that stout republican Samuel. They got their king (even though the Lord was all against it). So do so many people to-day.

I have every confidence that this book will stimulate other readers as it has stimulated me. If we want the best things, we must search where Mr Marvin searches—however much we argue about details of method. I only hope we shall not be led astray into the path which he once or twice looks on with interest—a path which has lately had its attractions for such dissimilar philosophers as Mr Aldous Huxley and Mr Somerset Maugham. I refer to mysticism. If most of our drives are part intellectual, part sensual, the mystic drive appears to be a self-annihilation of both mind and body. If you're tired of the body, go and do a bit of mathematics. If you're tired of the mind, go and climb an Alp. But, whatever you do, don't get tired of both at the same time.

H. E. H.

## South Latitude

(*"South Latitude", by F. D. Ommanney. Longmans, Green, 9s. 6d.*)

This is a quite remarkably good book. It belongs to a genre which has become more highly developed in our day than ever before—what one may call the highest form of personal journalism. Peter Fleming's books, Vincent Sheean's *In search of History*, many of the best modern novels, and now this book of Ommanney's—they are really astonishingly similar in method and spirit. They are all produced by sensitive and intelligent people writing vividly and truly about direct experience; direct experience which is described without any transformation, just for its own interest, and which usually begins by being a little bizarre.

Ommanney's book is one of the best of its kind. He is writing about whaling expeditions in the Antarctic and the actuality is remarkable. One seldom gets such a first-hand impression of things seen, felt, smelt. And through the book there comes continuously the sense that the author possesses a particularly pleasant character.

C. P. S.

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